MMI 2: Mobile Human-Computer Interaction

Visualization and Interaction Techniques for Small Displays

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Lectures

#	Date	Topic
1	19.10.2011	Introduction to Mobile Interaction, Mobile Device Platforms
2	26.10.2011	History of Mobile Interaction, Mobile Device Platforms
3	2.11.2011	Mobile Input and Output Technologies
4	9.11.2011	Mobile Input and Output Technologies, Mobile Device Platforms
5	16.11.2011	Mobile Communication
6	23.11.2011	Location and Context
7	30.11.2011	Mobile Interaction Design Process
8	7.12.2011	Mobile Prototyping
9	14.12.2011	Evaluation of Mobile Applications
10	21.12.2011	Visualization and Interaction Techniques for Small Displays
11	11.1.2012	Mobile Devices and Interactive Surfaces
12	18.1.2012	Camera-Based Mobile Interaction
13	25.1.2012	Sensor-Based Mobile Interaction 1
14	1.2.2012	Sensor-Based Mobile Interaction 2
15	8.2.2012	Exam

Review

- What is conceptual model extraction?
- Differences heuristic evaluation and think aloud?
- Why is mobile evaluation difficult?
- Example?
- Categories of rules to guide design / evaluation?

Preview

- Visualization for mobile devices
- Mobile Web browsers
- Locating off-screen objects
- Improving touch screen accuracy

VISUALIZATION FOR MOBILE DEVICES

Visualization for Mobile Devices

- External visualization and human visual processing to simplify task and reduce cognitive load
  - Better decisions in less time
- Examples: patient records, aircraft maintenance
- Influence of context, distraction
- Untrained users, minimal learning
- Limited display size
  - Limit amount of information per screen
  - Distribute information between screens
- Match the user's task (e.g. locate a POI)
- Aesthetics, fun, engagement

Chittaro: Visualizing Information on Mobile Devices. IEEE Computer, 2006.

Aspects of Visualization Design

- Mapping: visually encoding information
  - Turning data into graphics
  - Make data and relationships easy to visually perceive
- Selection: relevance to the task
  - Missing data: wrong decisions
  - Unnecessary data: visual clutter, cognitive effort
- Presentation: screen layout
  - Using available screen space effectively

Chittaro: Visualizing Information on Mobile Devices. IEEE Computer, 2006.

Aspects of Visualization Design

- Interactivity: explore and rearrange information
  - Zooming, filtering, highlighting, etc.
- Human factors: visual perception and cognition
  - Mental models
  - Delay
- Evaluation
  - Consider user, context, task, goal, visualization

Chittaro: Visualizing Information on Mobile Devices. IEEE Computer, 2006.

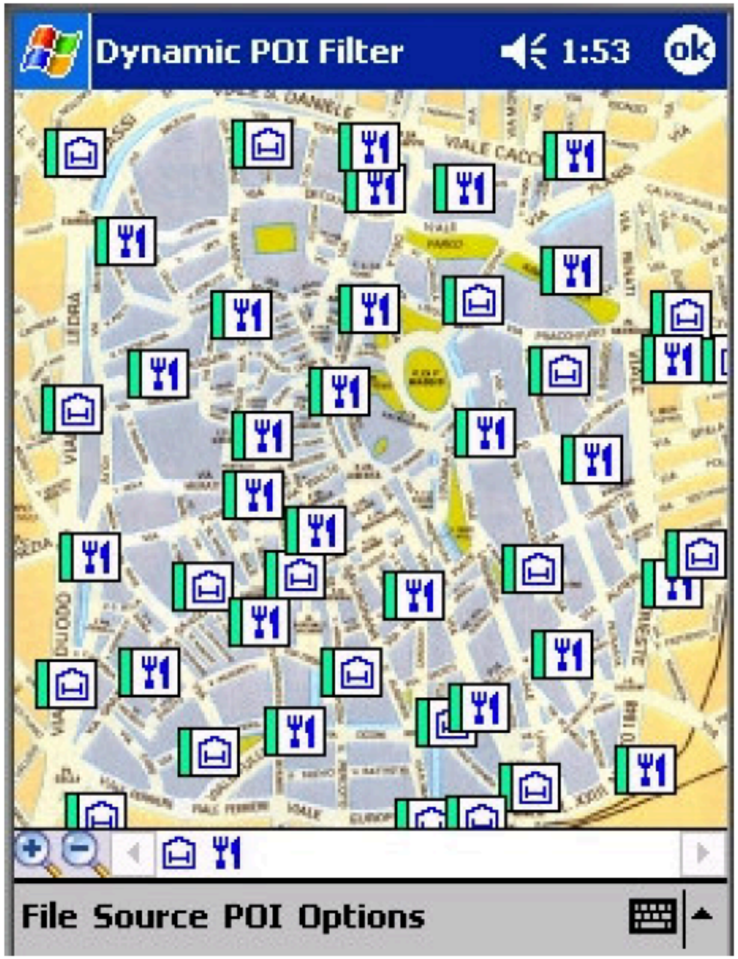
Mapping: Visually Encoding Information

- Turning data into graphics
  - Making conceptually important aspects perceptually important
  - Precise and consistent mapping
- Possible visual features
  - Length
  - Width
  - Depth
  - Size
  - Position
  - Orientation
  - Curvature
  - Shape
  - Color
  - Intensity
  - Transparency
  - Icon
  - Movement
  - Speed
  - Flicker
  - Animation

Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

Mapping Example

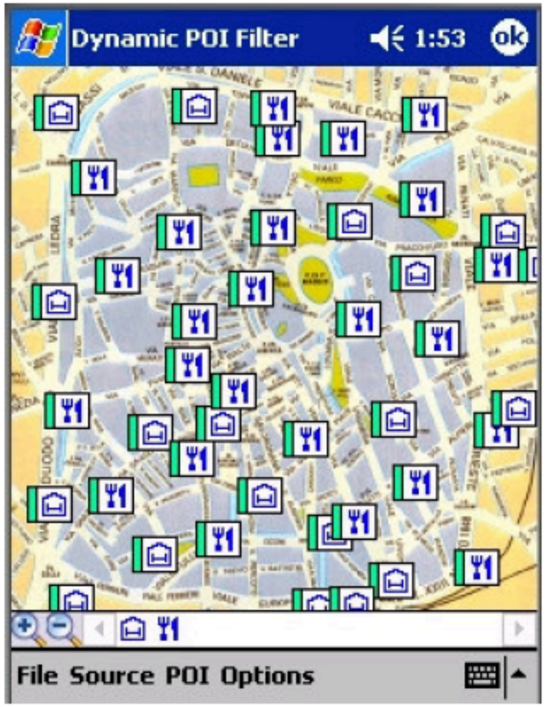
- Point of Interest (POI)
- POI type → Icon
- POI location → Position

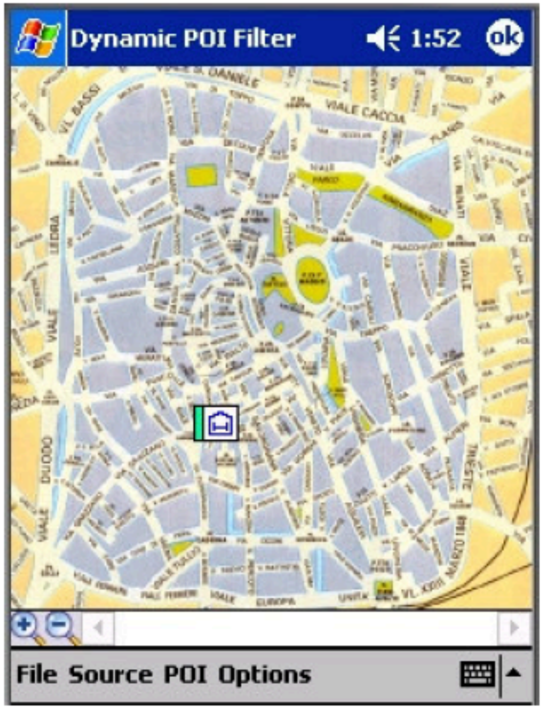


Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

Selection: Relevance to the Task

- Missing data: wrong decisions
- Unnecessary data: visual clutter, cognitive effort
- Example: mobile city guides



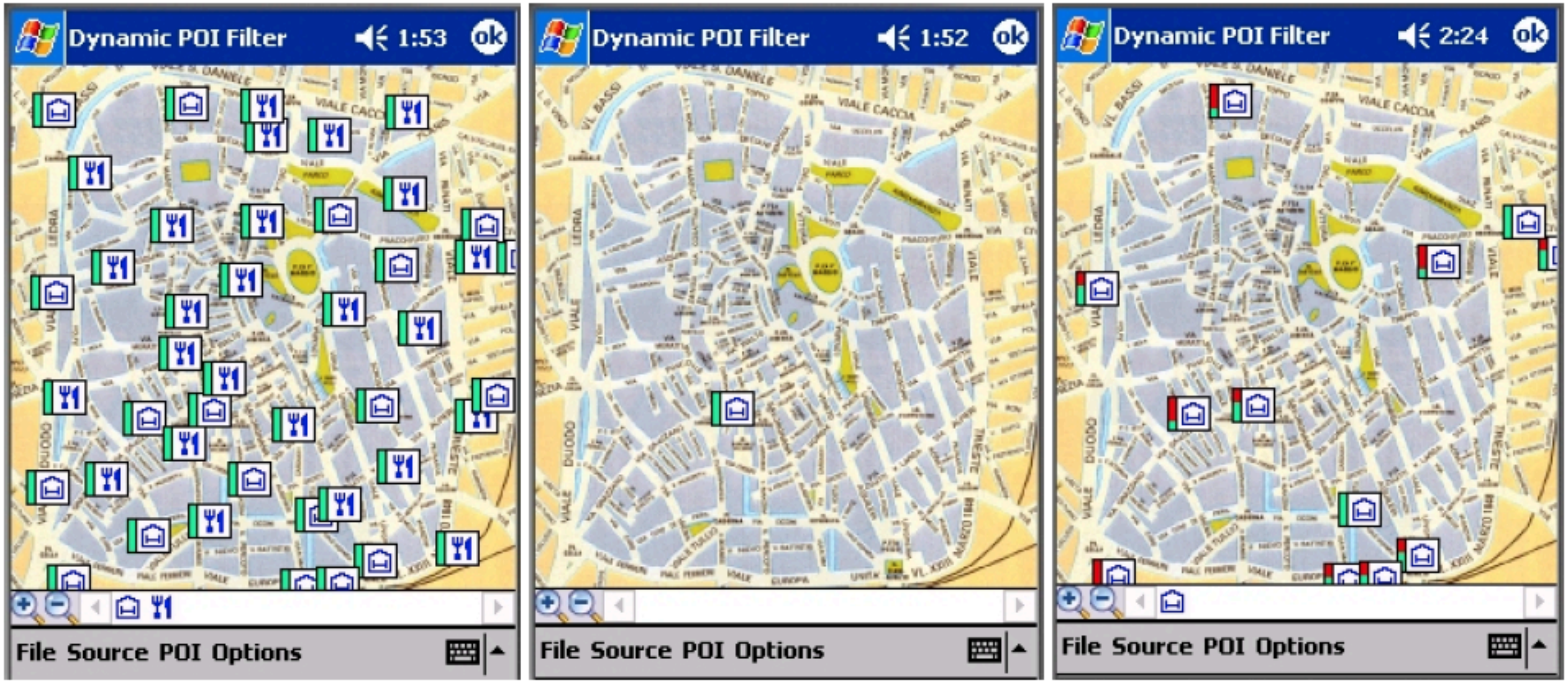


reduce number of candidates: only draw POIs that satisfy constraints

Chittaro: Visualizing Information on Mobile Devices. IEEE Computer, 2006.

Selection: Relevance to the Task

- Problem: specify constraints appropriately
  - too strict limits flexibility
  - too loose leads to clutter

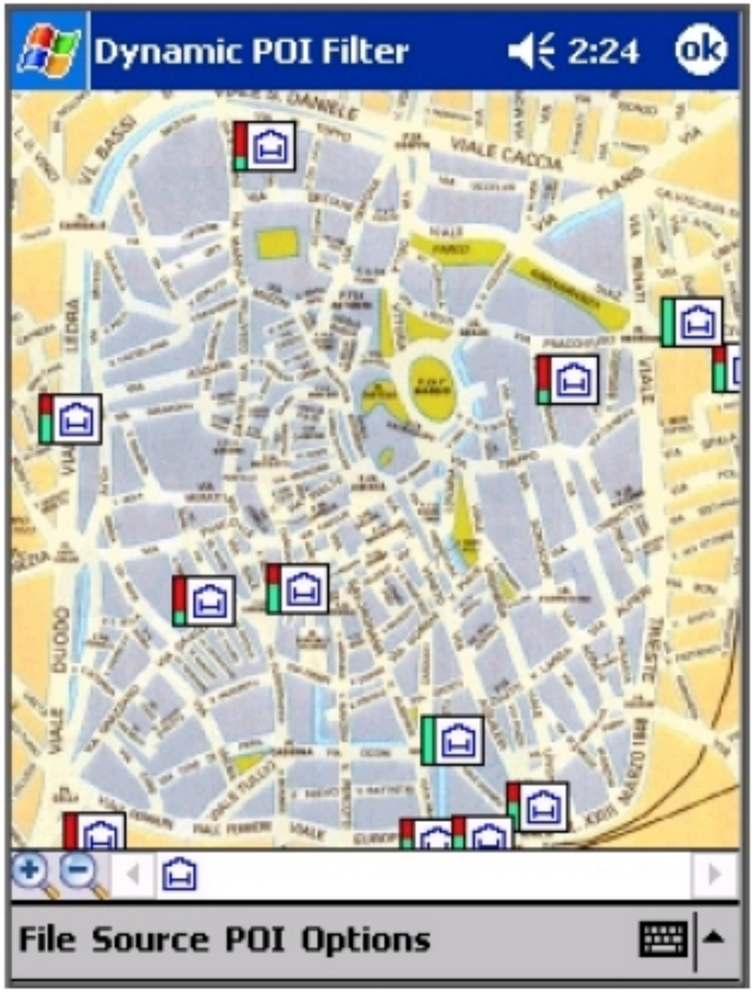


Chittaro: Visualizing Information on Mobile Devices. IEEE Computer, 2006.

Selection: Relevance to the Task

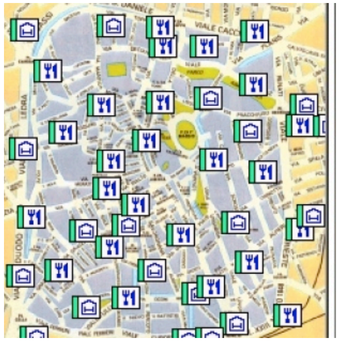
- Degree of relevance
  - Rather than binary on/off

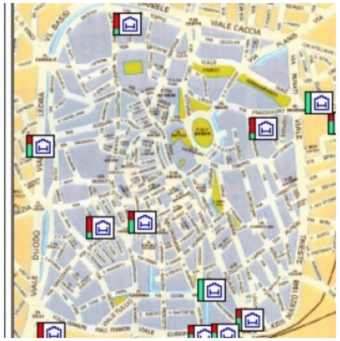
- Point of Interest (POI) → Icon with color bar
- POI Location → Position
- Satisfied / unsatisfied constraints → length of bar



Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

Selection: Relevance to the Task



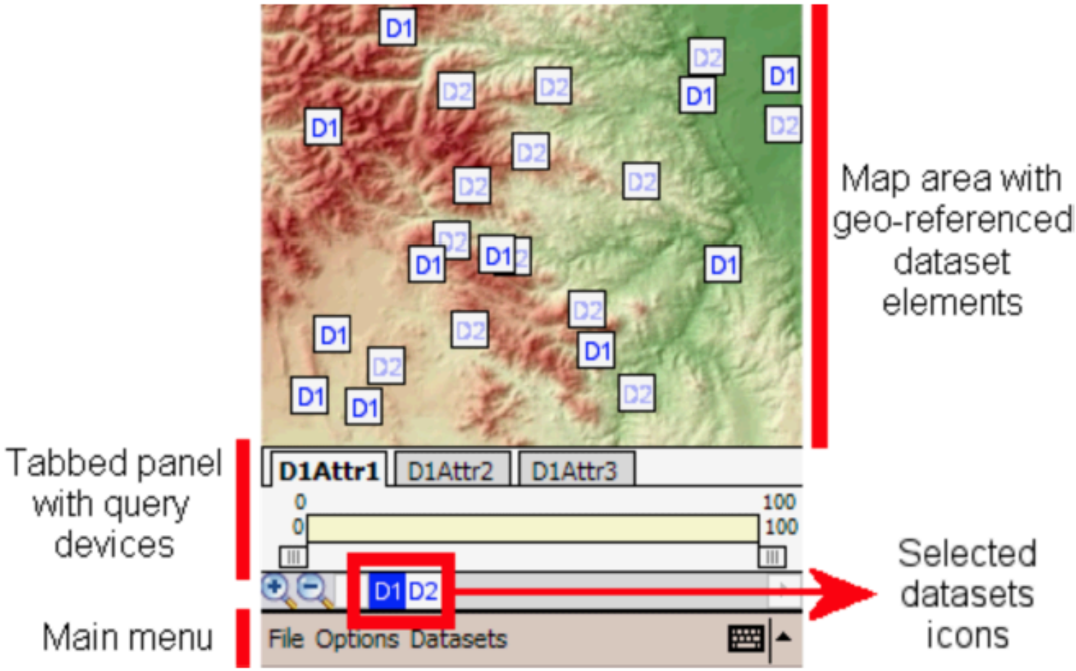


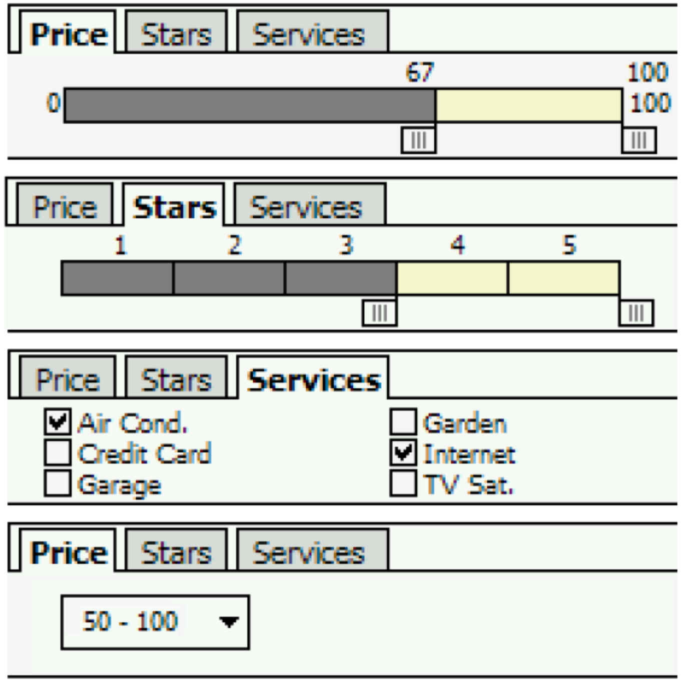
- Whether gradual or binary is better depends on task
- Binary on/off
  – Quickly reduce number of candidate POIs
  – Fast for simple tasks
  – High error rate for complex tasks
- Color bar
  – Keep partially matching POIs visible
  – Need to examine color bars of all POIs
  – Can refine queries

Burigat, Chittaro: Interactive Visual Analysis of Geographic Data on Mobile Devices based on Dynamic Queries. J.Vis.Lang.&Comp., 2008

Interactivity: Explore and Rearrange

- Example: Dynamic visual queries
  - Visualization updated in real-time
  - Tabbed panel, range sliders

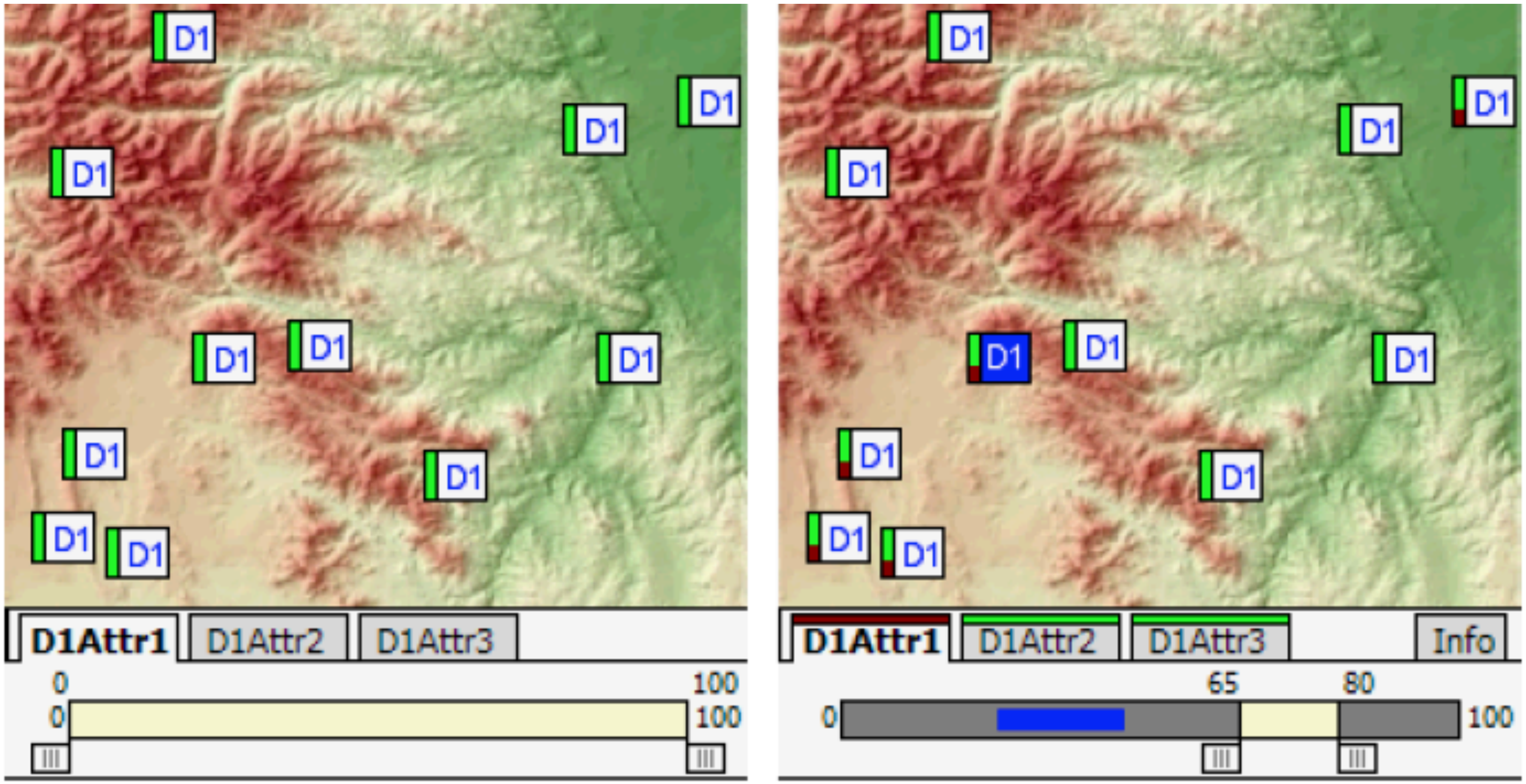




Burigat, Chittaro: Interactive Visual Analysis of Geographic Data on Mobile Devices based on Dynamic Queries. J.Vis.Lang.&Comp., 2008

Interactivity: Explore and Rearrange

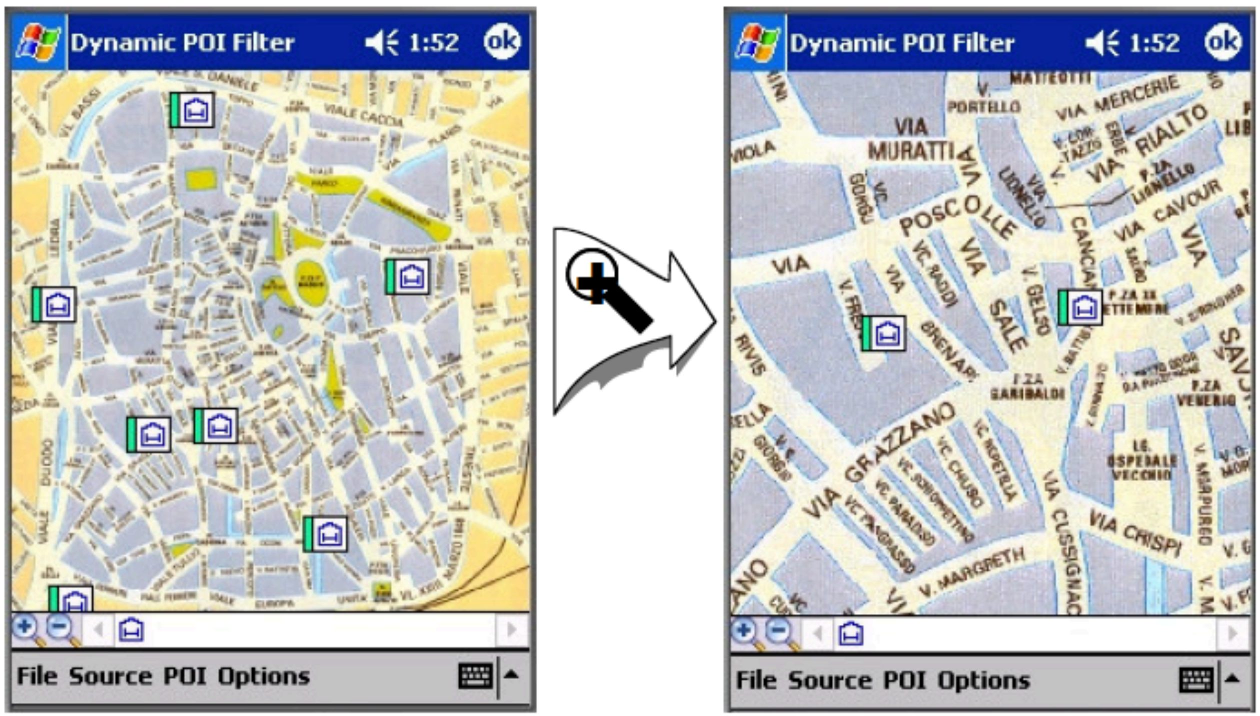
- Selecting a POI: POI value (blue), match (tab color)



Burigat, Chittaro: Interactive Visual Analysis of Geographic Data on Mobile Devices based on Dynamic Queries. J.Vis.Lang.&Comp., 2008

Presentation: Screen Layout

- Using available screen space effectively
- Example: either overview but not enough detail or detail but not enough overview



Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

Presentation: Screen Layout

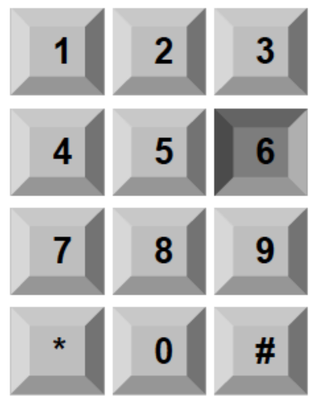
- User needs mechanisms to navigate UI
- Scrolling
  - Needs horizontal and vertical scrollbars
- Panning
  - Dragging content; OK for limited amount of navigation
- Switching between screens
  - Completely separates context and details
- Overview + detail
  - Two separate views, simultaneously shown
- Focus + context
  - Integrate context and detail, e.g. by distorting view, fisheye magnification

Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

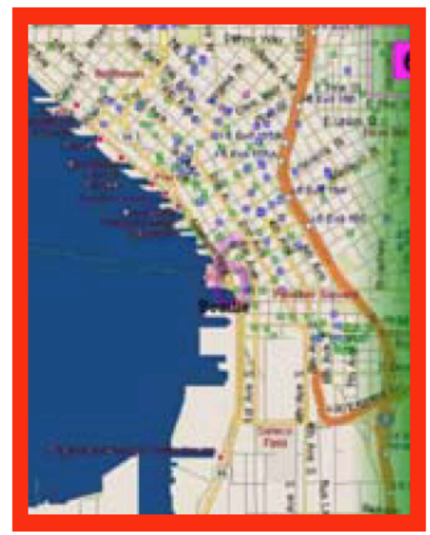
Switching between Screens: ZoneZoom

- Discrete screen areas mapped to keypad
- Recursive zooming and panning
- Allows one-handed operation

Initial view of the map



User presses on **6** key

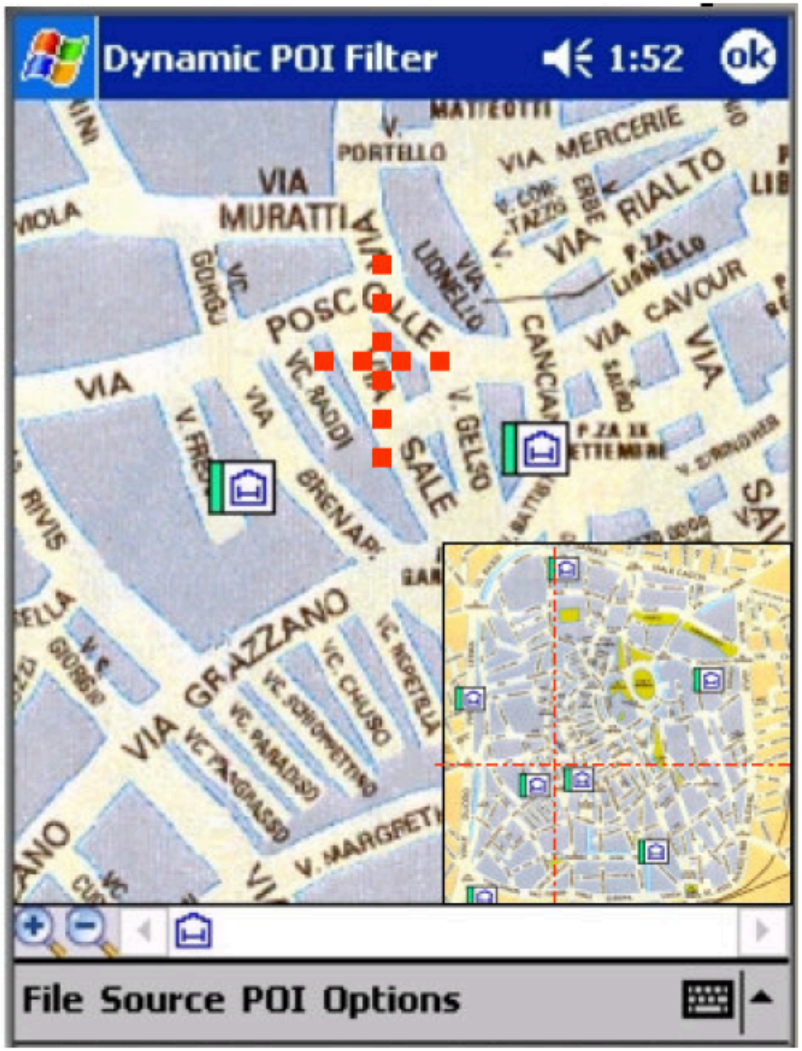


View pans and zooms to show sector **6**

Robbins, Cutrell, Sarin, Horvitz: ZoneZoom: Map Navigation for Smartphones with Recursive View Segmentation. AVI 2004.

Overview + Detail

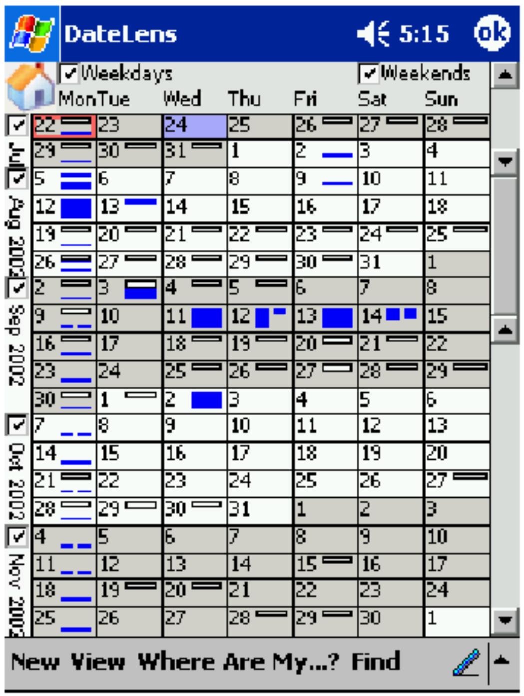
- Show details and separate overview
- Problems
  - Overview region difficult to read / too small
  - Overview takes away space from detail view
  - No integration of overview and detail

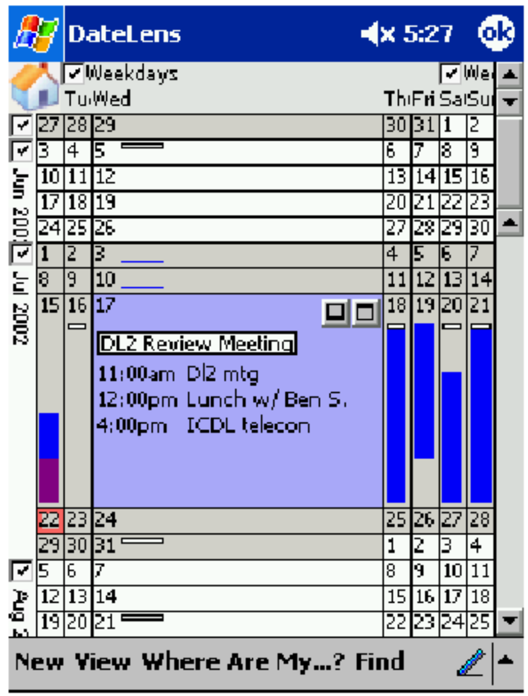


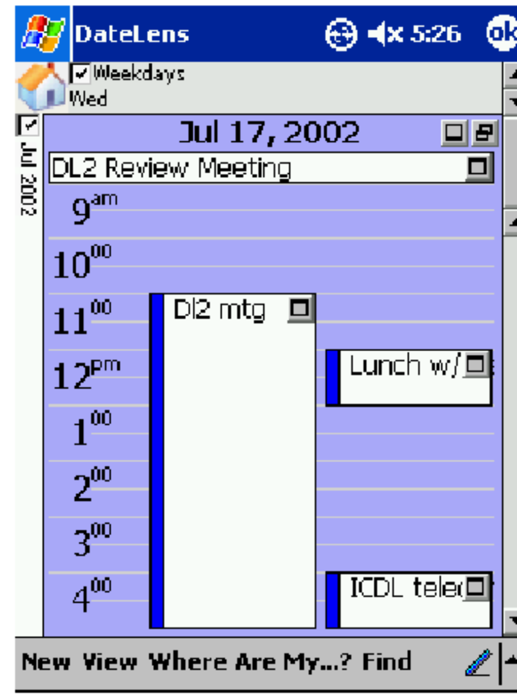
Chittaro: Tutorial: Information Vis. and Visual Interfaces for Mobile Devices. MobileHCI 2009.

Focus + Context: DateLens

- Calendar with fisheye view and semantic zoom
- Integrate context and detail, distortion







Bederson, Clamage, Czerwinski, Robertson: DateLens: A Fisheye Calendar Interface for PDAs. ACM TOCHI, 2004.

Human Factors: Visual Perception and Cognition

- Quickly and easily recognize and interpret a visualization
- Established field
- Important results
  - Brightness and contrast perception
    - Perception of brightness depends on visual context
  - Visual salience, preattentive processing
    - Certain features "pop out"
  - Suitability of visual features to encode quantitative information
    - E.g., length more accurate than area when judging quantities
  - Scene understanding
    - Humans can very quickly grasp a complex scene
  - Reading
  - Gestalt laws
    - E.g., grouping of elements, completion of partially visible elements

Aesthetics, Fun, Engagement

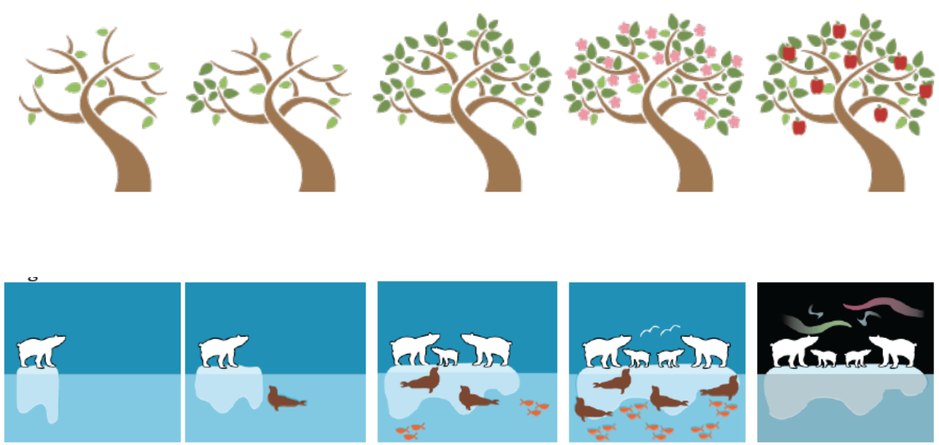
- Persuasive technology: support behavior change
- UbiFit Garden system



Consolvo, McDonald, Landay: Theory-Driven Design Strategies for Technologies that Support Behavior Change in Everyday Life. CHI 2009.

Aesthetics, Fun, Engagement

- Persuasive technology: support behavior change
- UbiGreen: giving feedback on transportation behavior



Consolvo, McDonald, Landay: Theory-Driven Design Strategies for Technologies that Support Behavior Change in Everyday Life. CHI 2009.

MOBILE WEB BROWSERS

Web Pages Don’t fit on Small Screens

Source: Patrick Baudisch

Web Pages Don't fit on Small Screens

- Solution approaches
  - Device-specific authoring
  - Automatic re-authoring
  - Client-side navigation

- Double tap to zoom into region or text column
  - Uses HTML DOM model

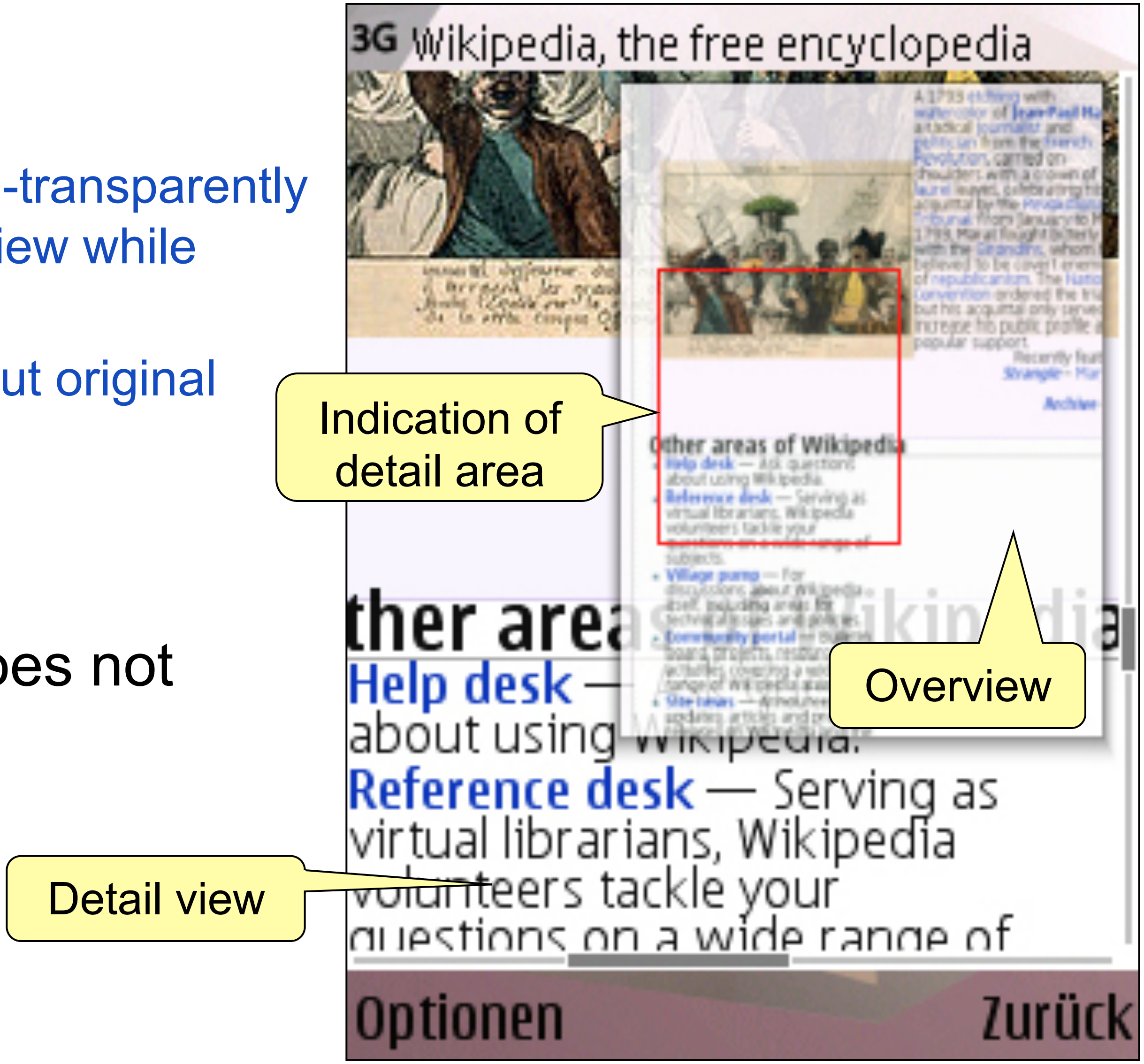
Source: Patrick Baudisch

Browsing Web Content

- Reorganize content in narrow vertical strip
  - Avoids horizontal scrolling
- 1-D browsing
- Narrow layout
  - Width = display width
  - Compact layout
  - Original layout destroyed
  - Little overview

Context in Focus Display

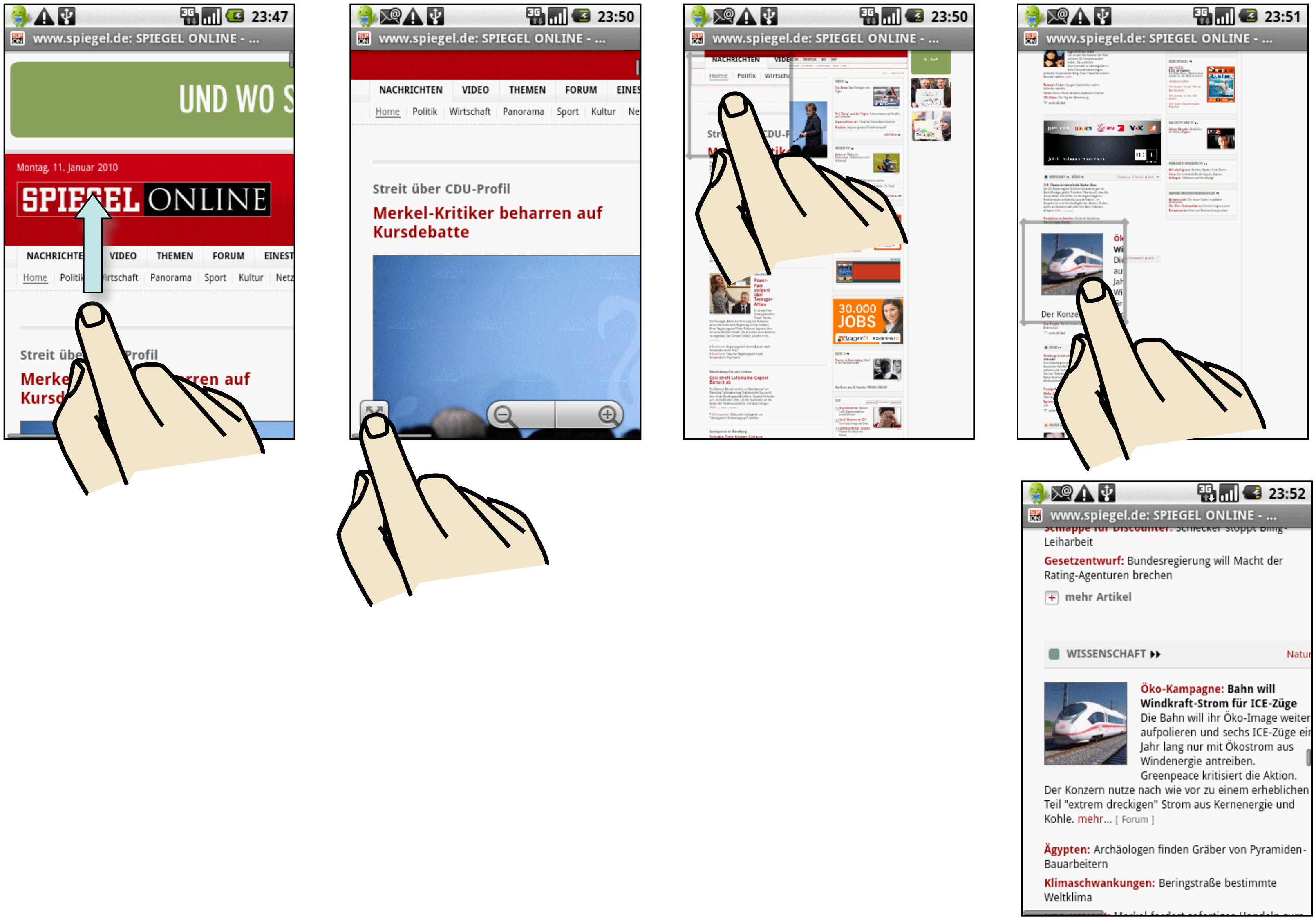
- Nokia MiniMap
  - Overview is semi-transparently shown in detail view while scrolling
  - Content scaled but original layout preserved
- Even overview does not show whole page



Nokia Symbian Browser

- Overview embedded in detail view
- Semi transparent detail view

Android Browser



Collapse-to-Zoom

Baudisch, Xie, Wang, Ma: *Collapse-to-zoom: Viewing web pages on small screen devices by interactively removing irrelevant content.* UIST '04.

- Zoom into arbitrary rectangular areas
- User's knowledge about relevance of areas

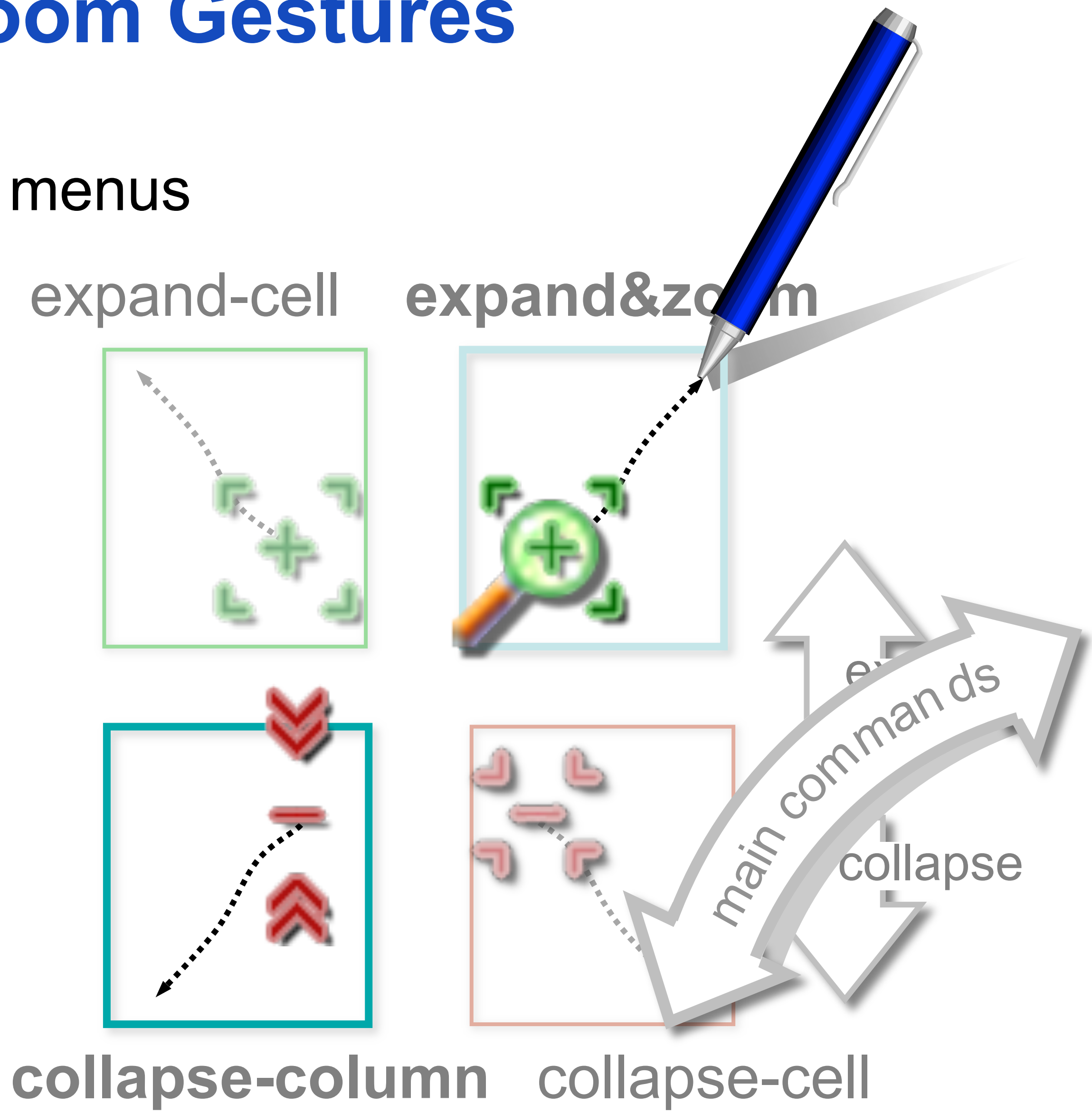
relevant → zoom in

irrelevant → collapse

Source: Patrick Baudisch

Collapse-to-Zoom Gestures

- Similar to marking menus
- Browser gestures
- Distinguish from vertical panning



Source: Patrick Baudisch

Collapse-to-Zoom Walkthrough

Expand-and-zoom gesture…

Source: Patrick Baudisch

Collapse-to-Zoom Walkthrough

Leads to fully readable detail view

Source: Patrick Baudisch

Summary Thumbnails

Lam, Baudisch: *Summary Thumbnails: Readable Overviews For Small Screen Web Browsers.* CHI 2005.

Source: Patrick Baudisch

Summary Thumbnails – Process HTML

- For each object on the web page
  - Count # of lines
  - Increase font size
  - Reduce text to preserve # of lines
- Text reduction strategies
  - Remove words from the end
  - Remove most commonly occurring word (frequency dictionary)

original page

scale font up

reduce text to fit

Source: Patrick Baudisch

LOCATING OFF-SCREEN OBJECTS

Halo (Baudisch & Rosenholtz, 2003)

Baudisch, Rosenholtz: Halo: A Technique for Visualizing Off-Screen Locations. CHI 2003.

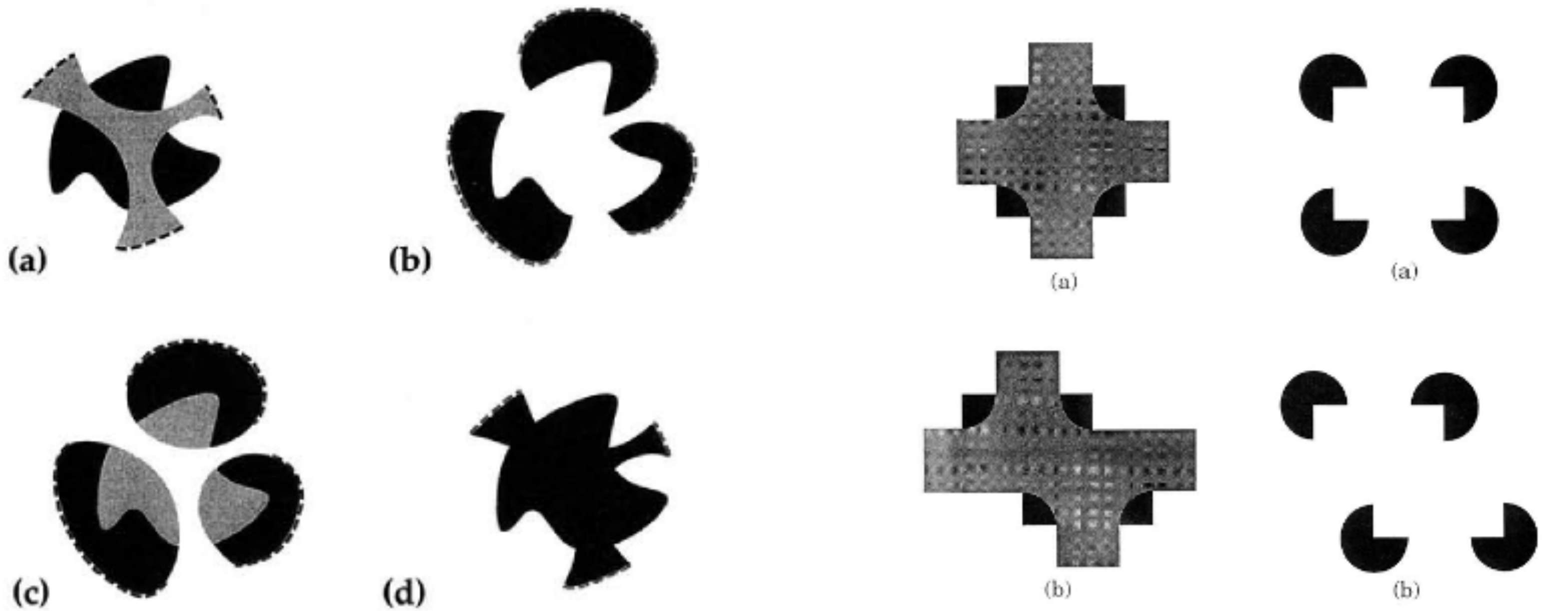
Source: Patrick Baudisch

Streetlamp Metaphor

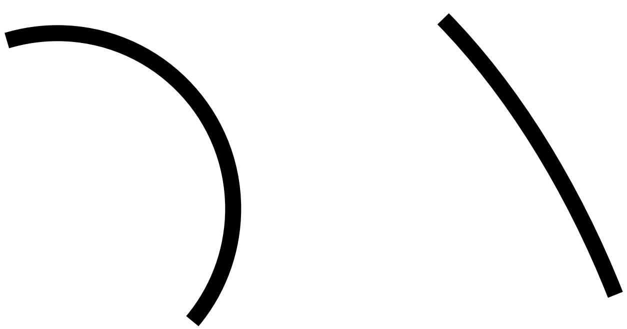
- Aura visible from distance
- Aura is round
- Overlapping auras aggregate
- Fading of aura indicates distance

Source: Patrick Baudisch

Gestalt Laws: Perceptual Completion



Shipley and Kellman 1992



Source: Patrick Baudisch

User Study: Halos vs. Arrows

arc/arrow fading off

same selectable size

legend

halo ring

distance from display border

Source: Patrick Baudisch

1. Locate Task

click at expected location of off-screen targets

Source: Patrick Baudisch

2. Closest Task

click arrow/arc or off-screen location closest to car

Source: Patrick Baudisch

3. Traverse Task

click on all targets in order, so as to form the shortest delivery path, beginning at the car

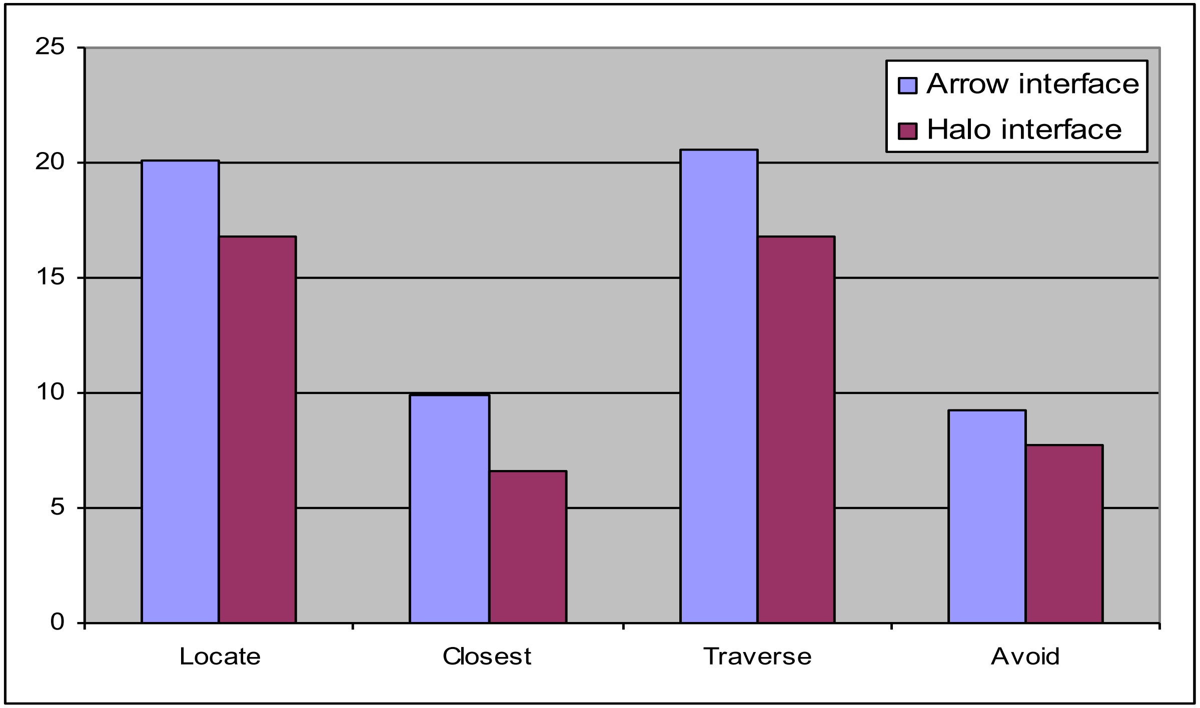
Source: Patrick Baudisch

4. Avoidance Task

click on hospital farthest away from traffic jams

Source: Patrick Baudisch

Task Completion Time

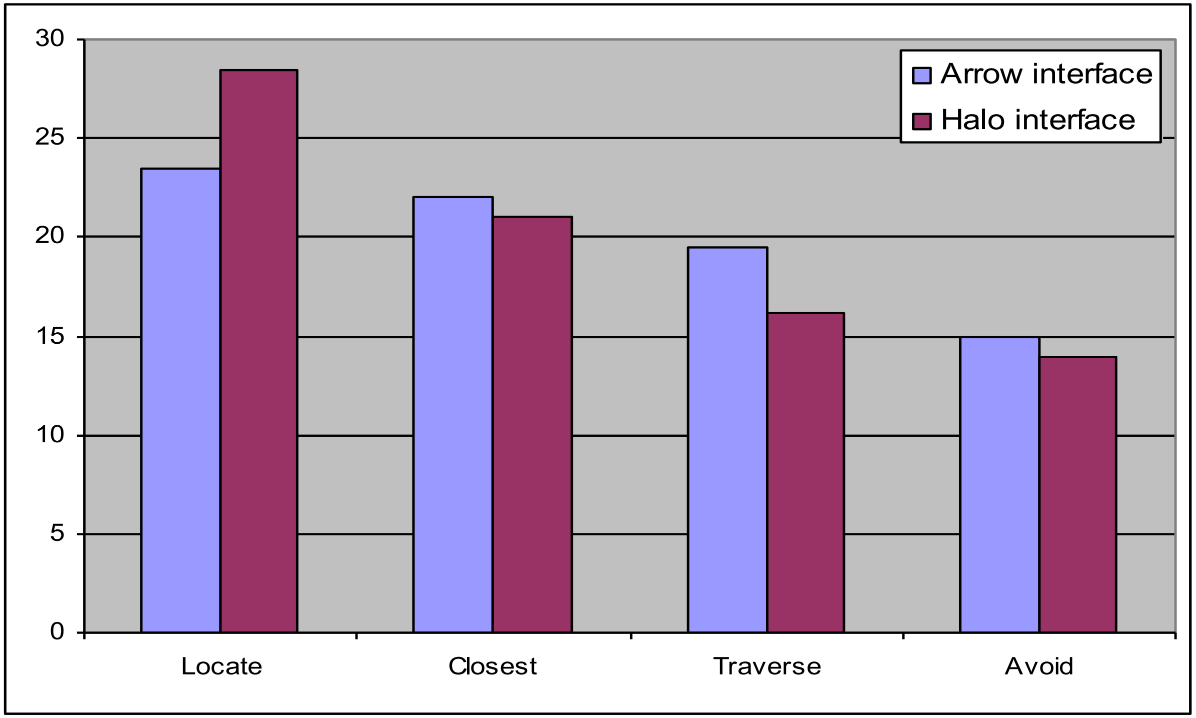


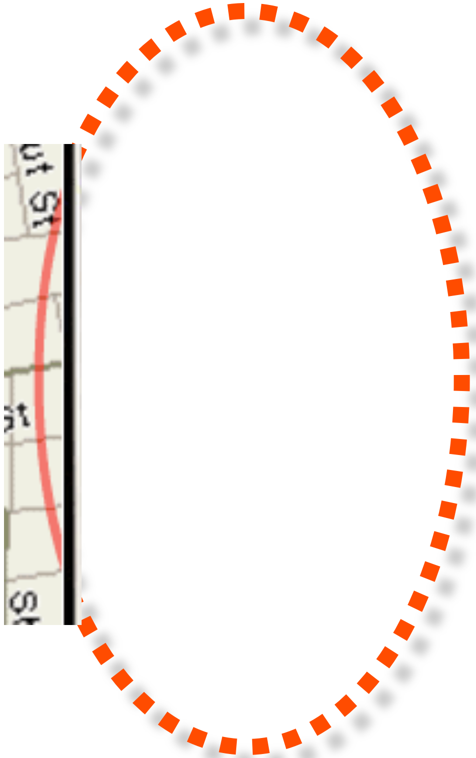
Task	Arrow interface	Halo interface
Locate	20.1 (7.3)	16.8 (6.7)
Closest	9.9 (10.1)	6.6 (5.3)
Traverse	20.6 (14.1)	16.8 (8.7)
Avoid	9.2 (4.7)	7.7 (5.8)

Source: Patrick Baudisch

Error Rate

Task	Arrow interface	Halo interface
Locate	23.5 pixels (21.6)	28.4 pixels (33.8)
Closest	22% (42%)	21% (41%)
Traverse	97.4 pixels (94.7)	81.0 pixels (96.7)
Avoid	15% (35%)	14% (34%)

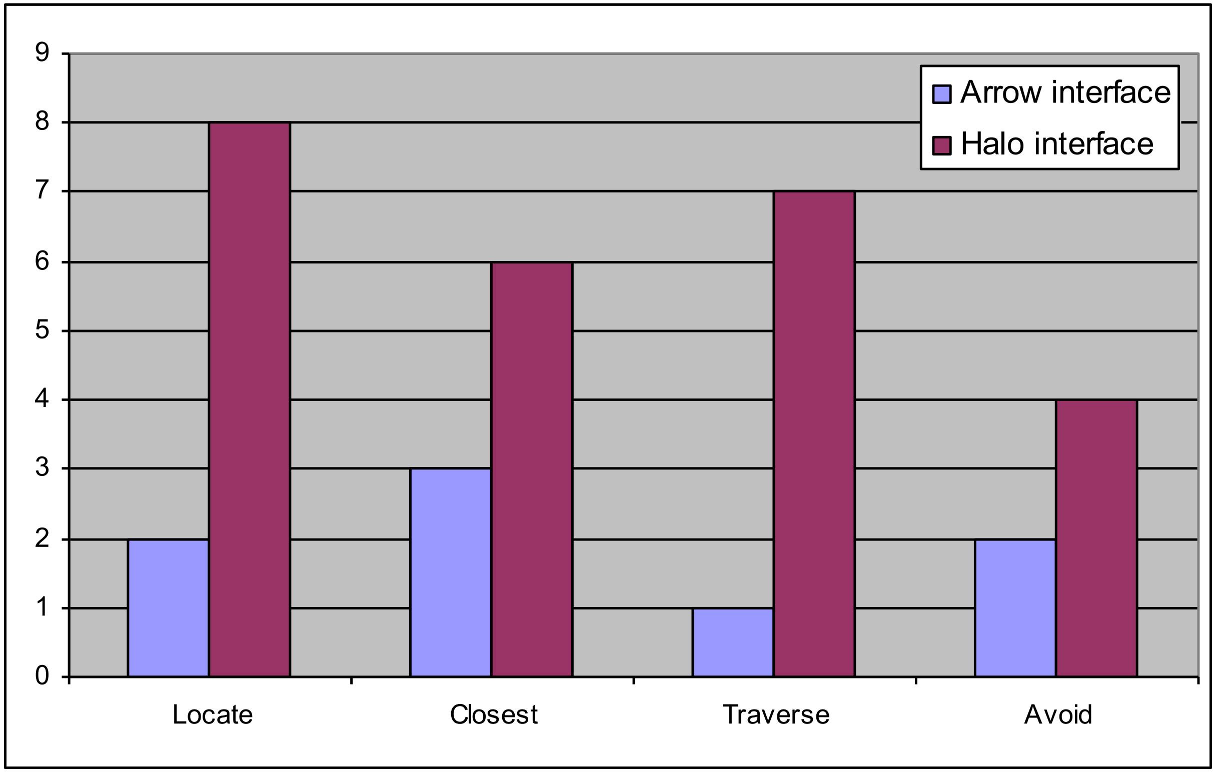




- Participants underestimated distances by 26%
- Participants saw ovals
- To compensate: width += 35%

Source: Patrick Baudisch

Subjective Preference



Source: Patrick Baudisch

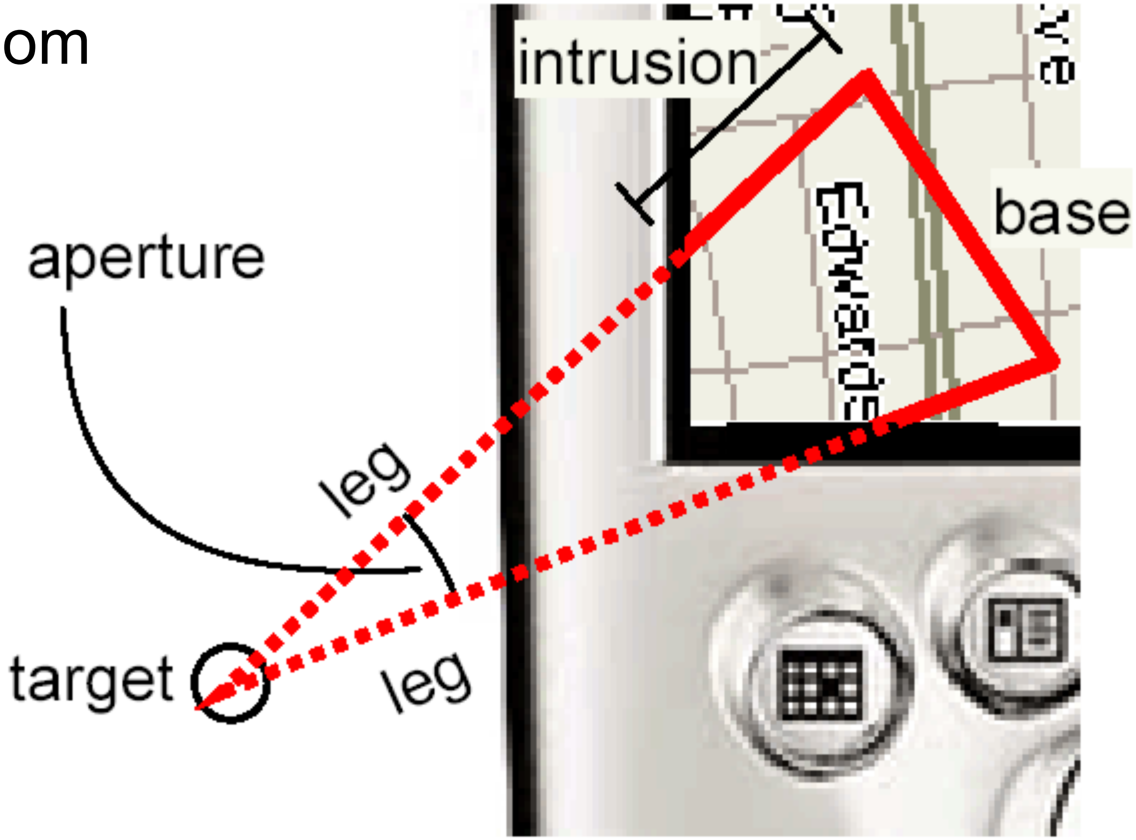
Limitation of Halo: Clutter

- Clutter from overlapping or large number of halos
- Wedge: Isosceles triangles
  - Legs point towards target
  - Rotation, aperture
- No overlap
  - Layout algorithm adapts rotation and aperture

Gustafson, Baudisch, Gutwin, Irani: Wedge: Clutter-Free Visualization of Off-Screen Locations. CHI 2008.

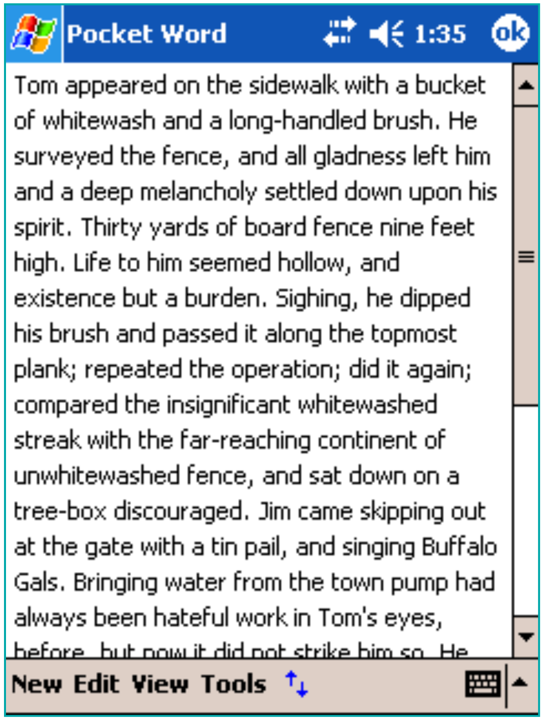
The Wedge

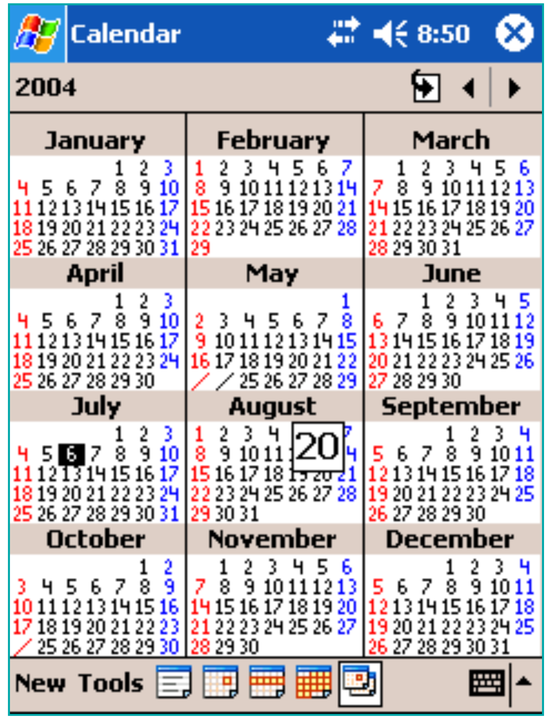
- Degrees of freedom
  - Rotation
  - Intrusion
  - Aperture

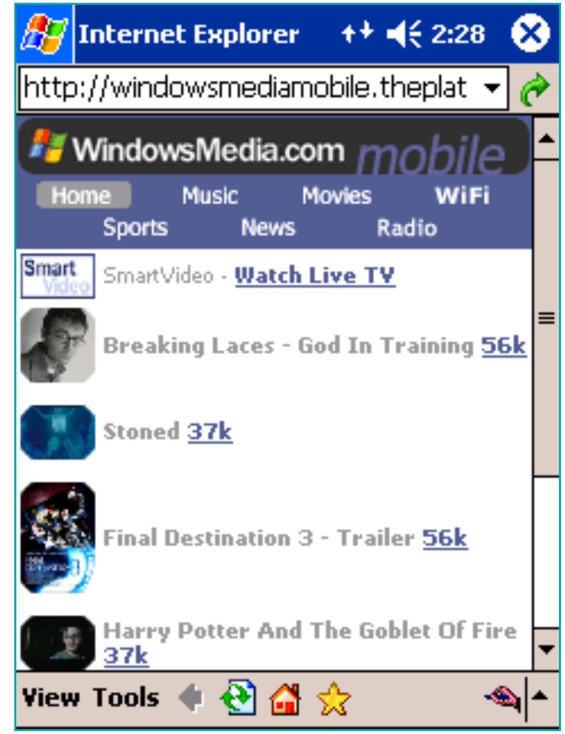


IMPROVING TOUCH SCREEN ACCURACY

Small Displays → Small Targets



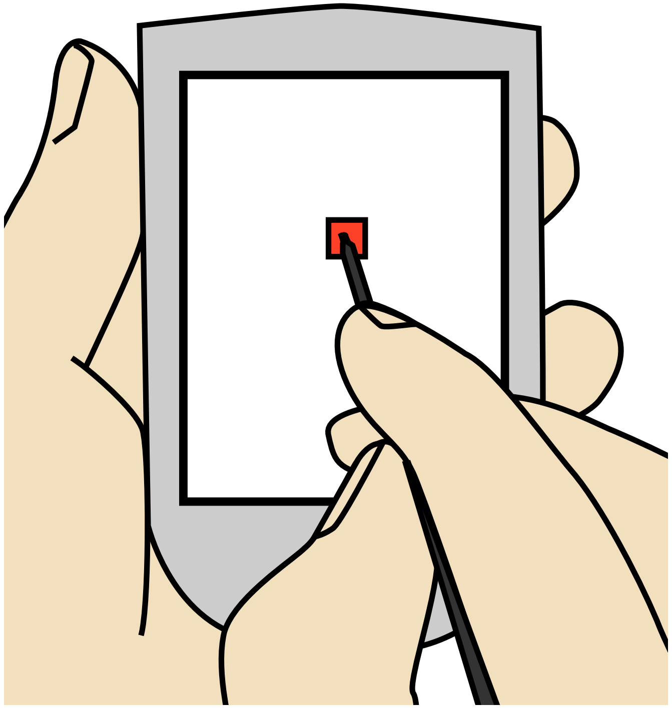




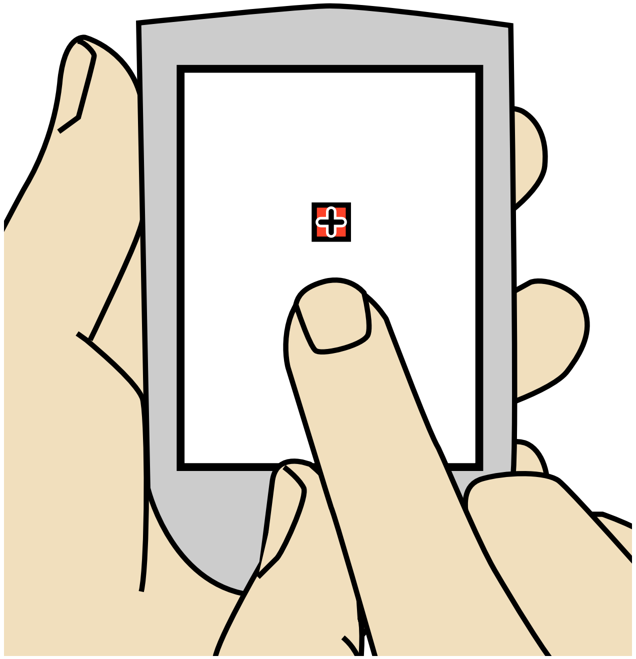
Source: Patrick Baudisch

Stylus vs. Direct Finger Input

- Stylus or pen
  - Grabbing stylus takes to long for short interactions
- Bare finger input
  - Unclear contact point, imprecise
  - Finger occludes target



Offset Cursor (Potter et al., 1988)



Potter, Weldon, Shneiderman: Improving the accuracy of touch screens: an experimental evaluation of three strategies. CHI 1988.

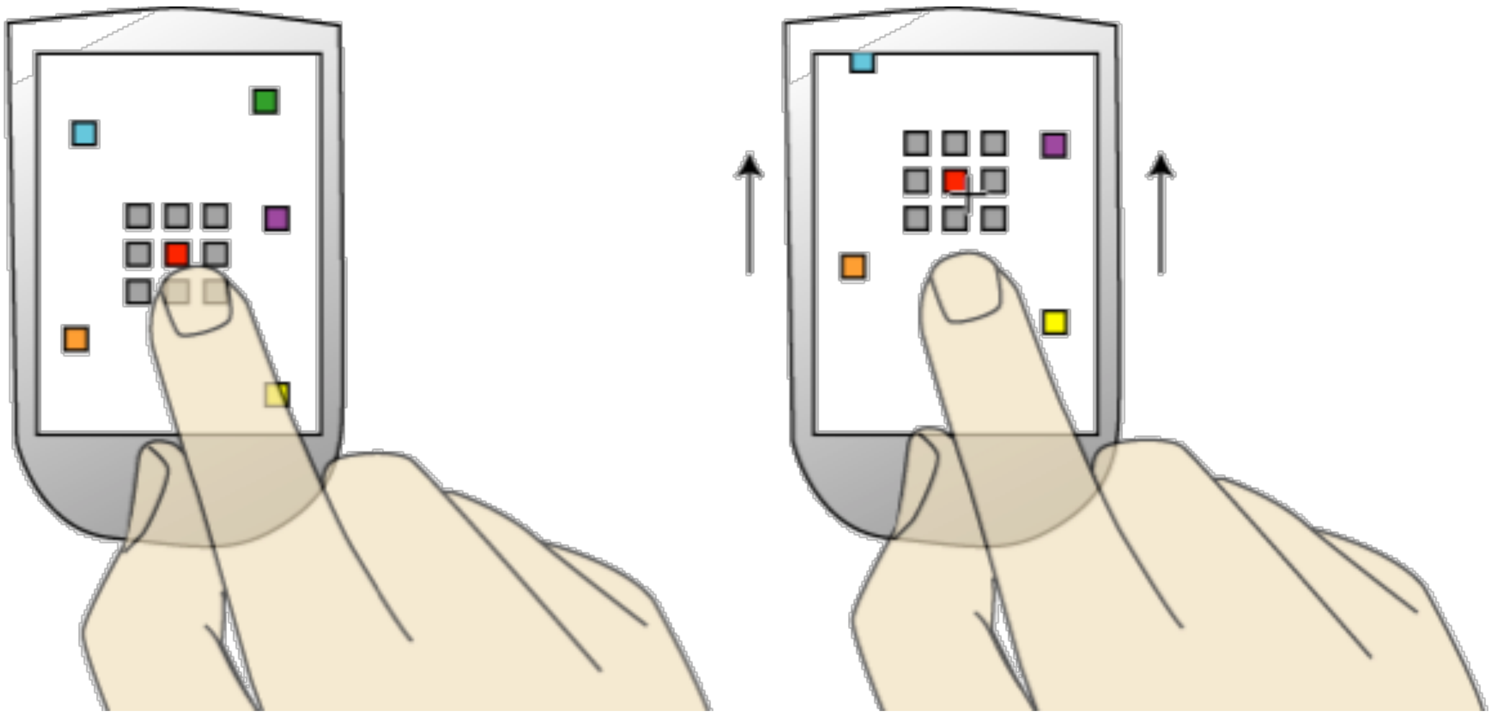
Disadvantages of this “software stylus”

1. No visual feedback until contact, need to estimate offset
2. Makes some display areas unreachable
3. Unexpected offset affects walk-up-and-use scenarios

Source: Patrick Baudisch

Shifting the Whole Screen

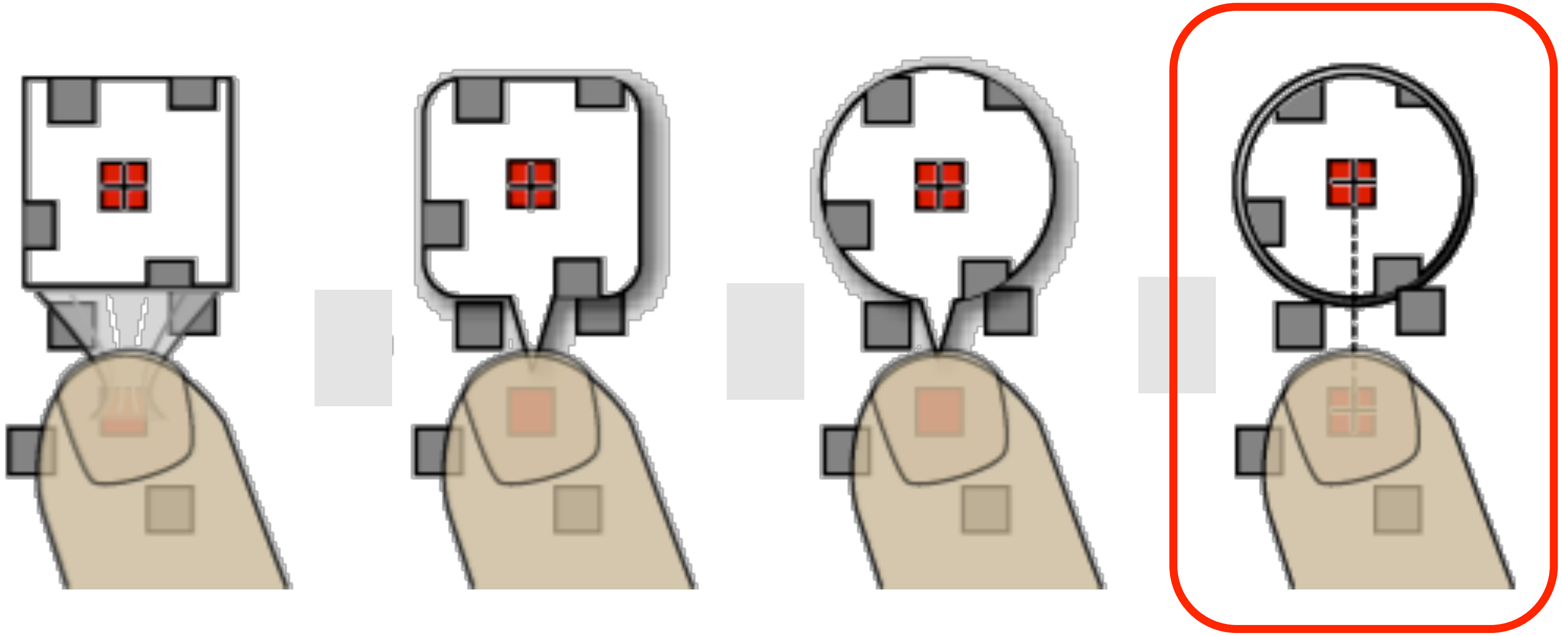
- Shifting the whole screen is distracting
- Disorients users, negatively impacts performance



Source: Patrick Baudisch

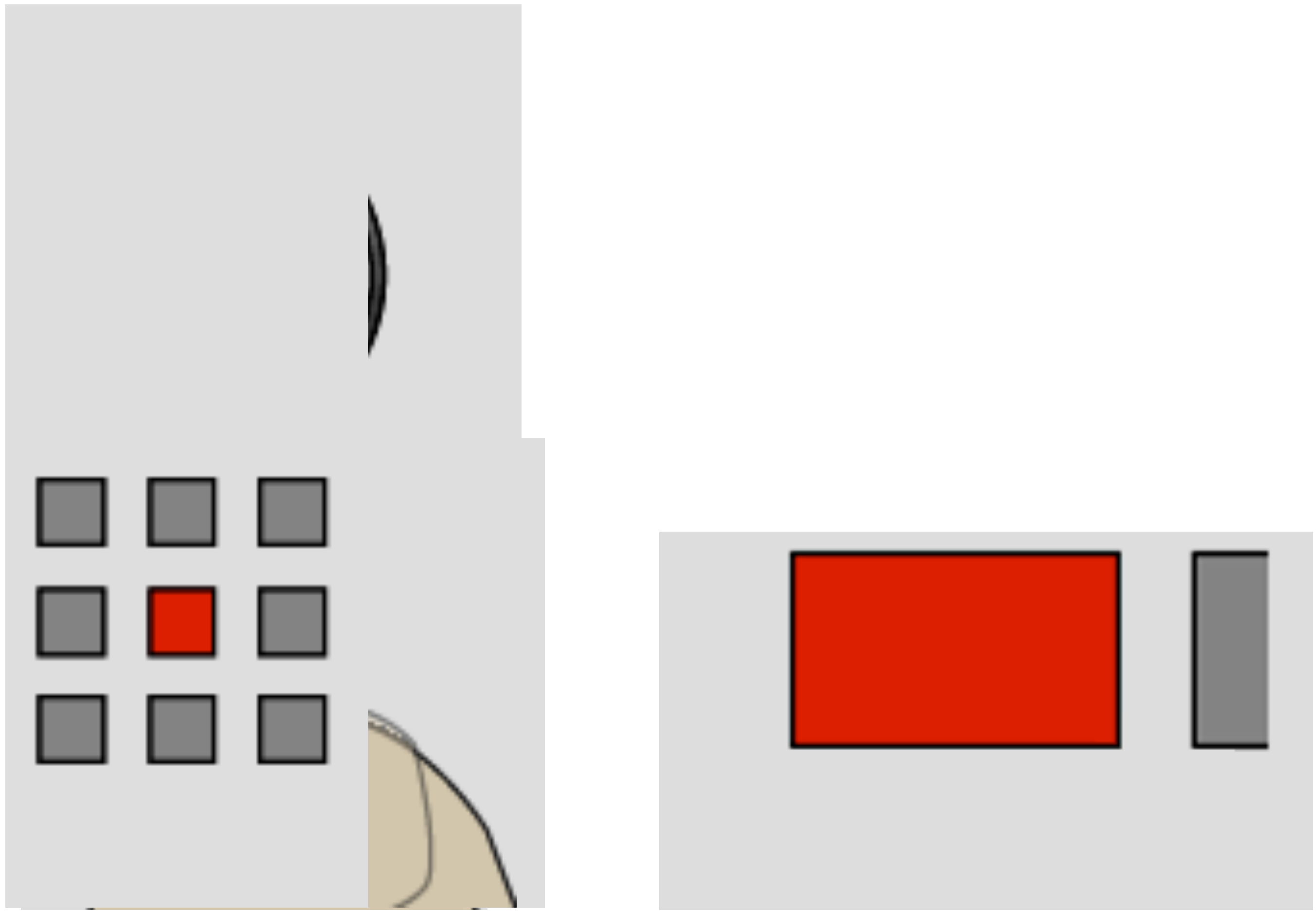
Shift Callout (Vogel & Baudisch, 2007)

- Only shift callout
- Enough context around target
- 26mm circular shape → occluded area under finger



Source: Patrick Baudisch

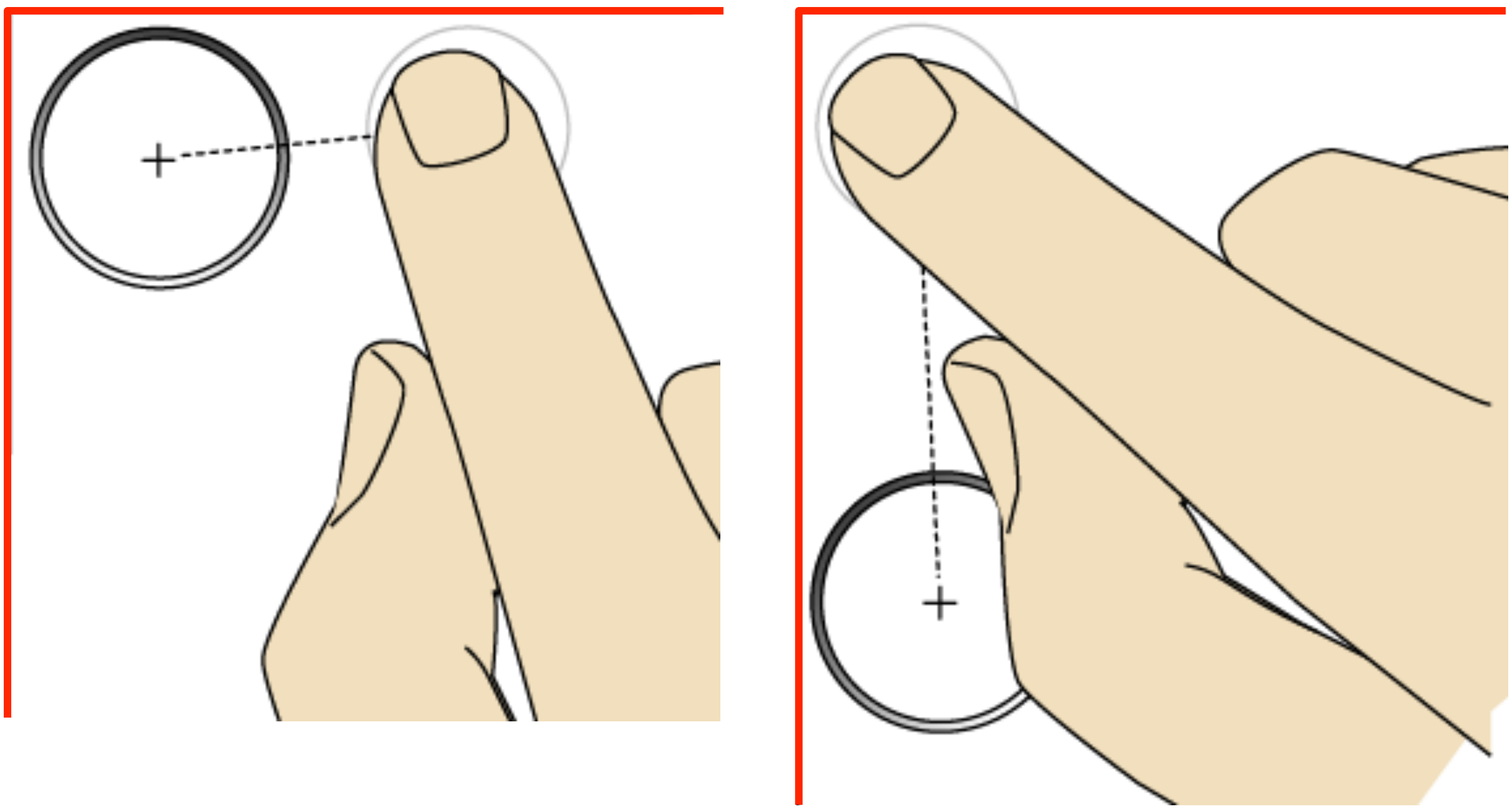
Shift Needed Only for Small Targets



no offset, click on the target itself

Source: Patrick Baudisch

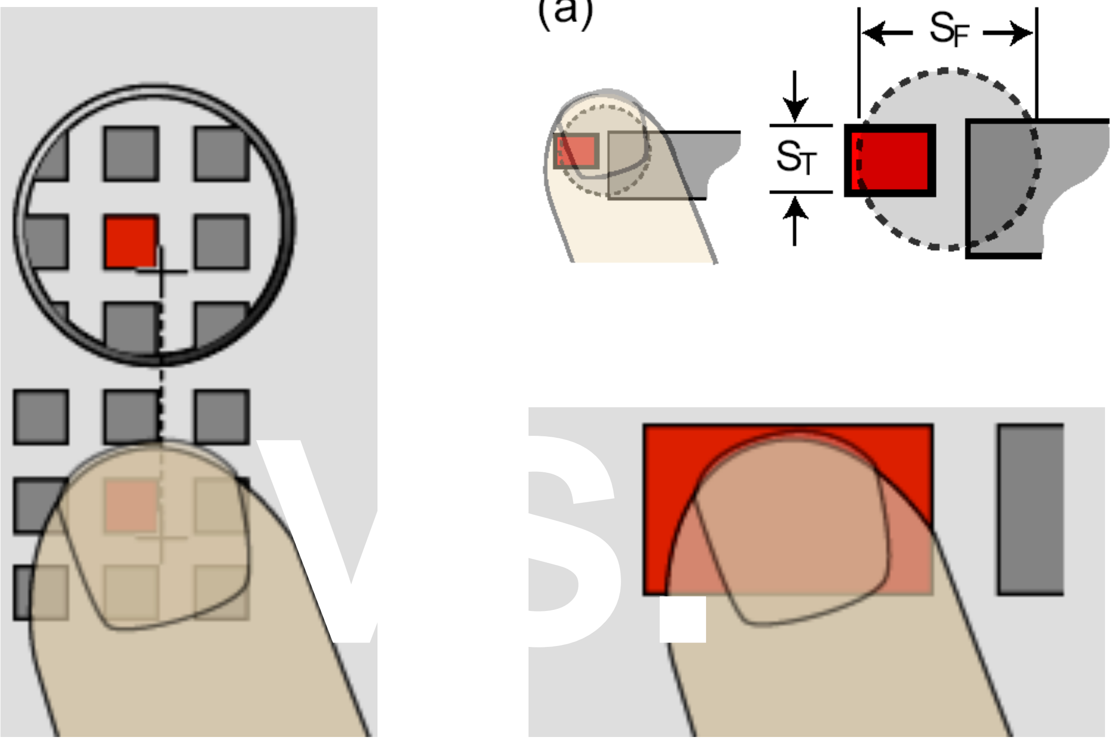
Corners and Edges

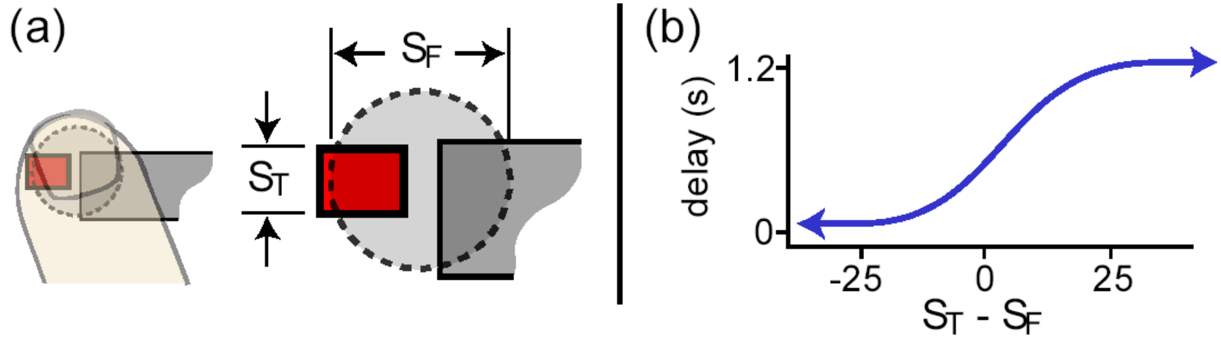


callout can go anywhere, no edge problems

Source: Patrick Baudisch

When to Show the Callout





S_T = target size

S_F = finger occlusion size

by default: dwell time (300 ms)

extension: larger target → longer dwell time

extension: shift learns dwell times

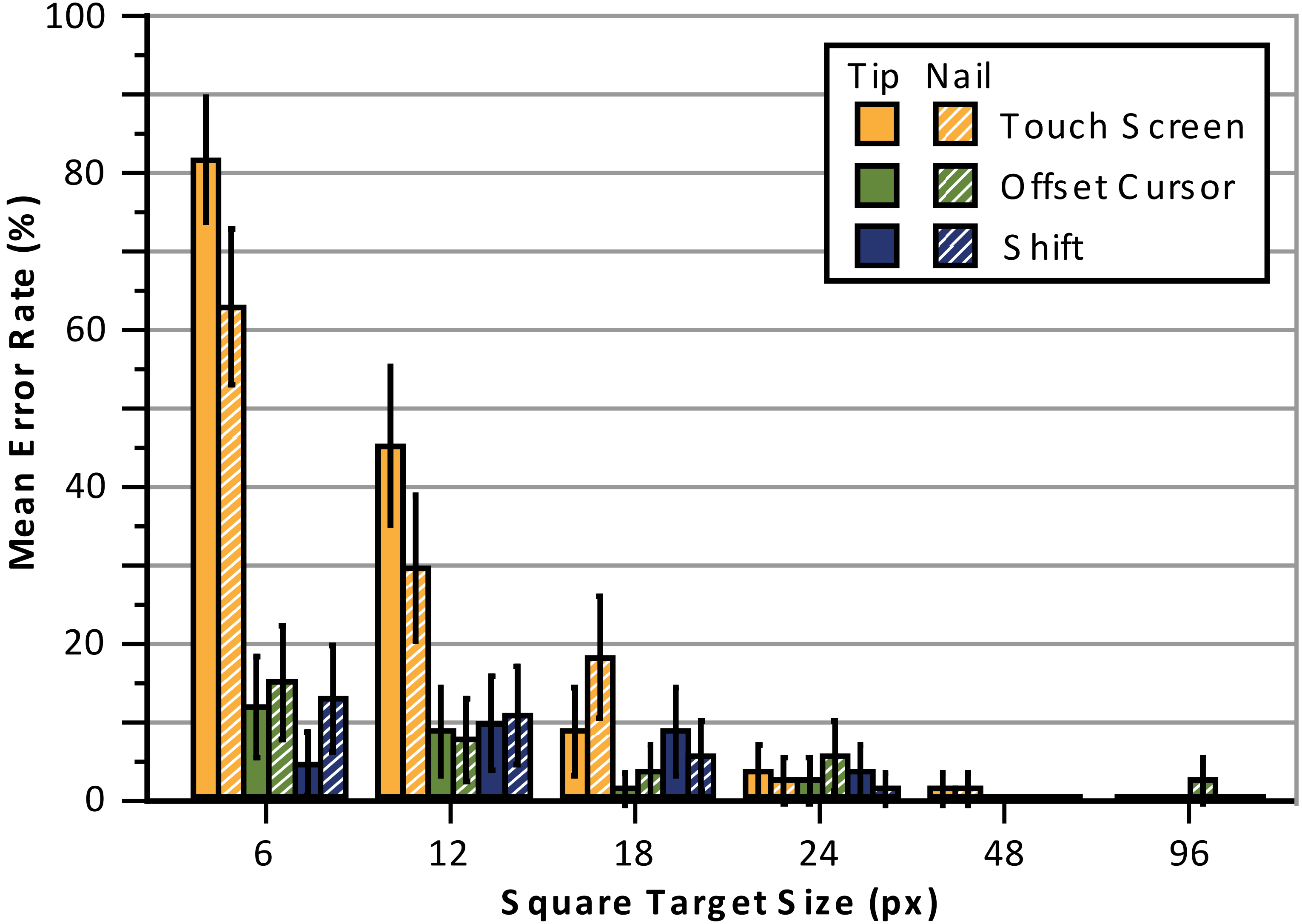
Source: Patrick Baudisch

Experiment: Shift vs. Offset vs. Touch

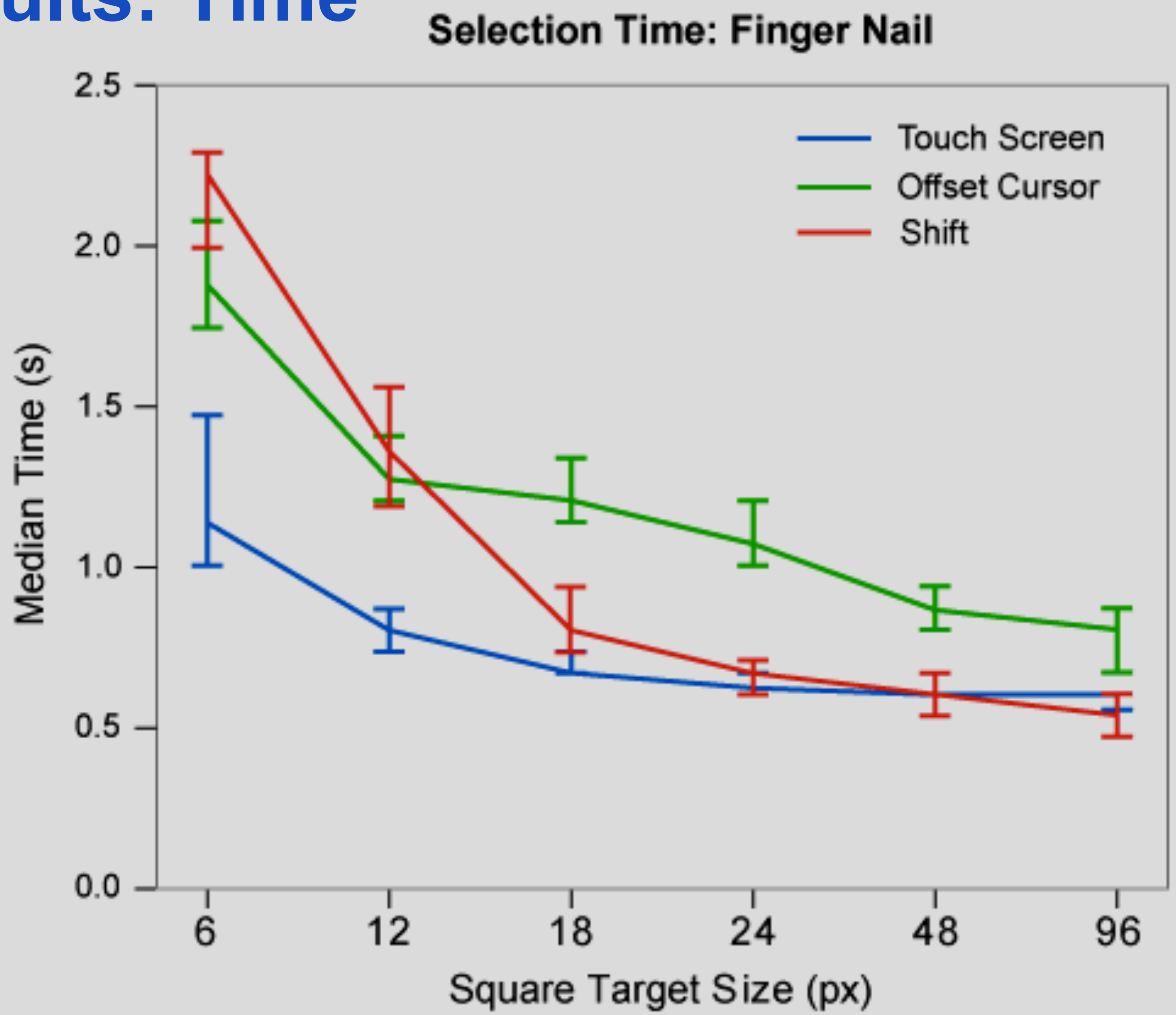
- Independent variables
  - 3 techniques: shift, offset, touch
  - 2 finger styles: nail, tip
  - 6 target sizes

Source: Patrick Baudisch

Results: Error Rate

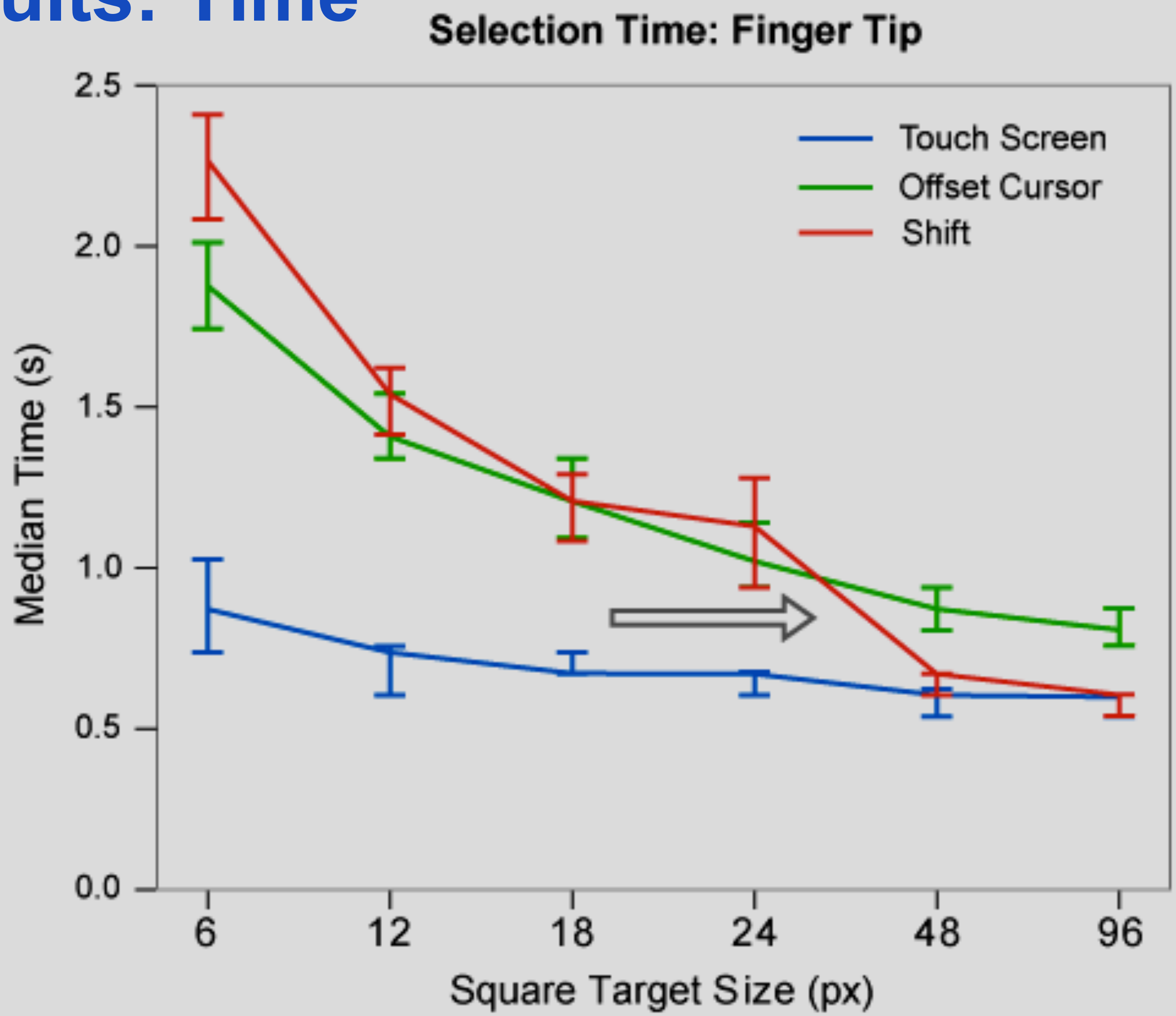


Results: Time



Source: Patrick Baudisch

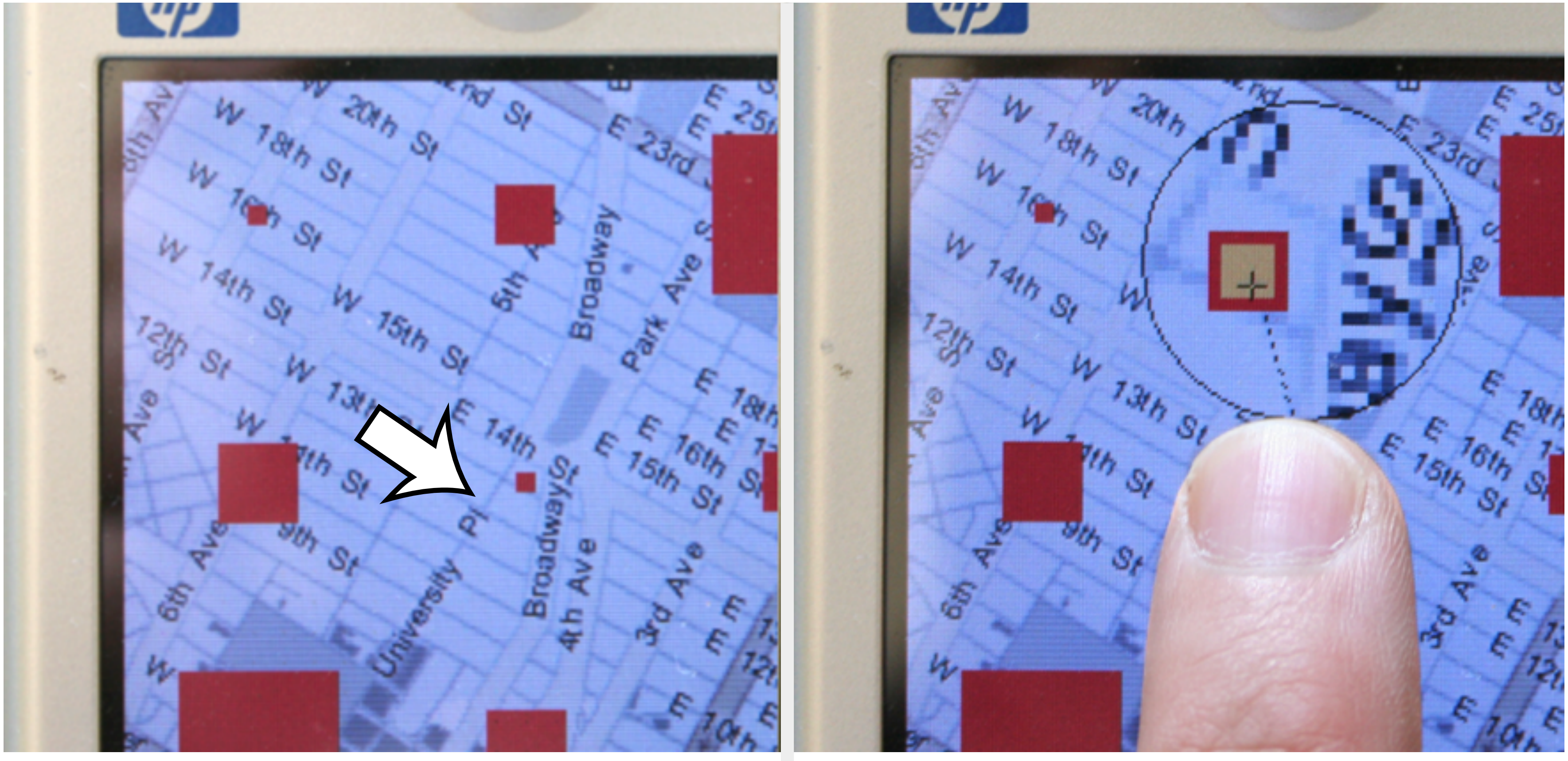
Results: Time



Source: Patrick Baudisch

Shift + Zoom

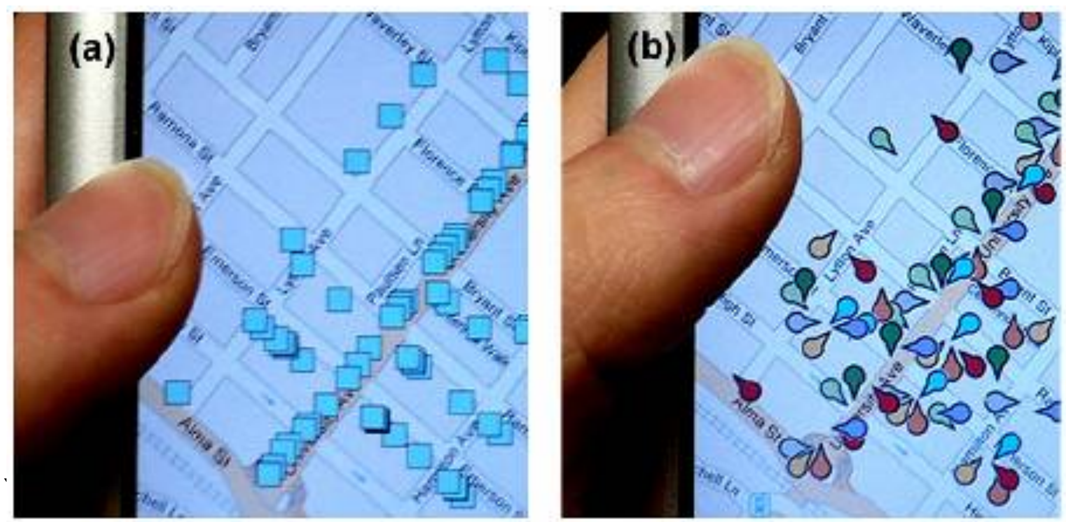
- Increased callout diameter to compensate for less context



Source: Patrick Baudisch

Escape: A Target Selection Technique Using Visually-cued Gestures

- Problem: Selecting a target that is surrounded by other selectable objects
- Solution: Icons in "Escape" indicate directions. A finger tap followed by a movement enables disambiguation.

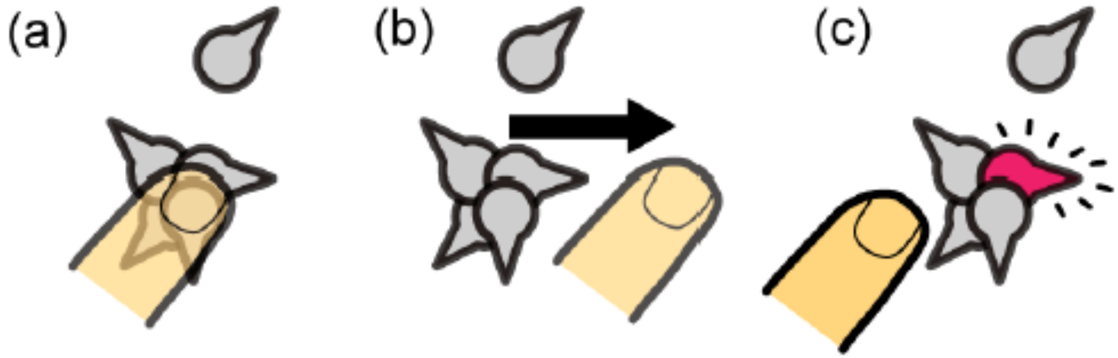


Selection Technique
Using Visually-cued Gestures, CHI 2008

Yatani, Partridge, Bern, Newman: Escape: A Target Selection Technique Using Visually-cued Gestures. CHI 2008.

Escape: A Target Selection Technique Using Visually-cued Gestures

- Icons in “Escape” indicate directions. A finger tap followed by a movement enables disambiguation.



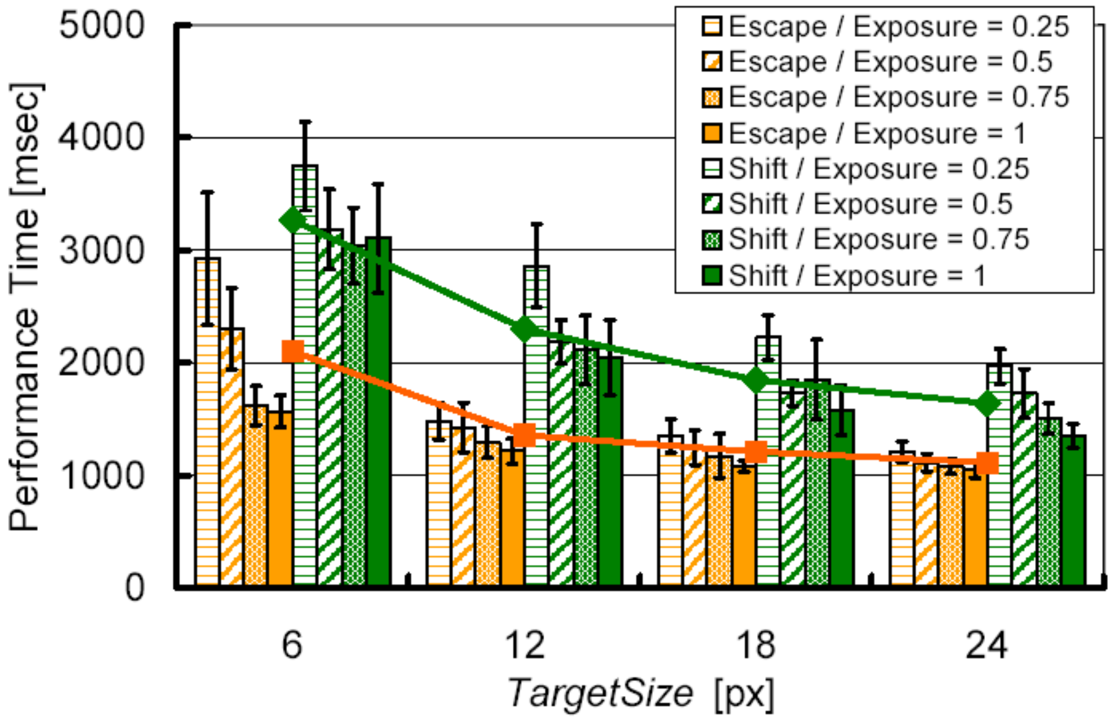
- Can handle 2.3 icons per square centimeter
- Find an assignment that separates gestures
  - Similar to graph coloring → NP-complete
  - “Escape” uses heuristic algorithm

http://www.youtube.com/watch?v=x3NeZswKkKw

Yatani, Partridge, Bern, Newman: Escape: A Target Selection Technique Using Visually-cued Gestures. CHI 2008.

Experiment: Escape compared to Shift

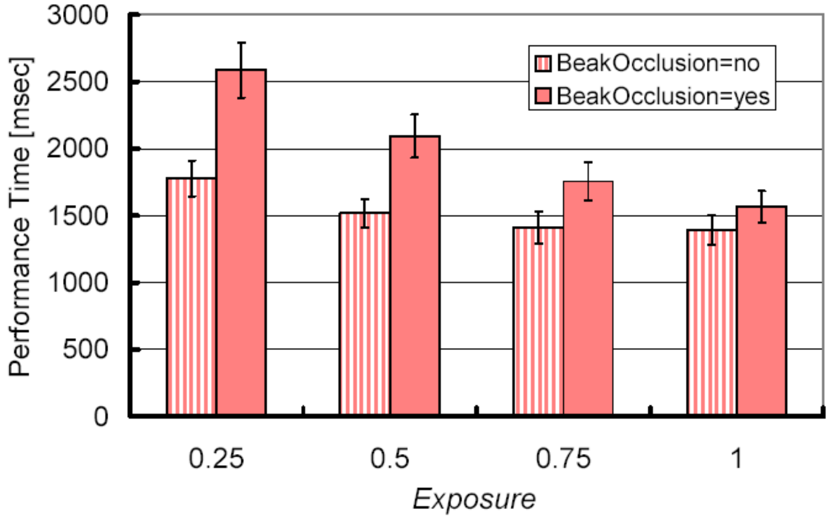
- Independent variables
  - Technique: Escape or Shift
  - Target size: 6, 12, 18, 24 pixels
  - Exposure (fraction of target visible): 0.25, 0.5, 0.75, 1
- Results
  - Escape significantly faster than Shift
  - No significant difference in error rate

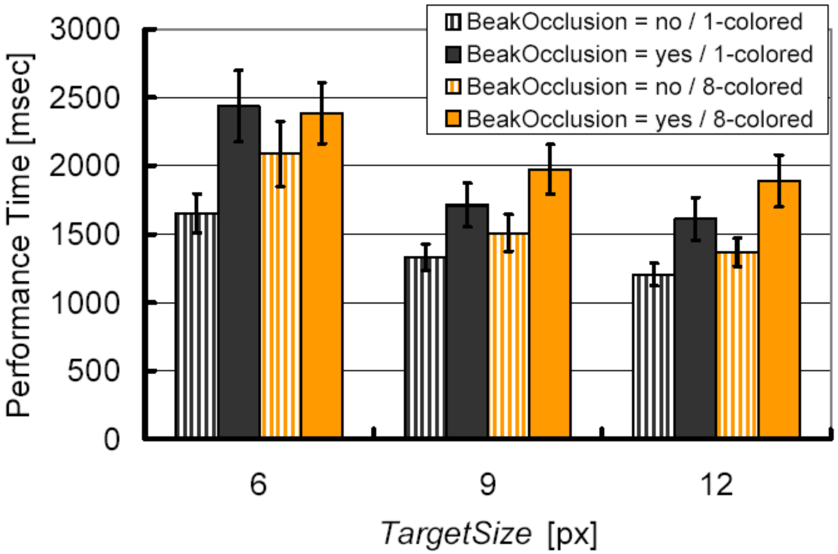


Yatani, Partridge, Bern, Newman: Escape: A Target Selection Technique Using Visually-cued Gestures. CHI 2008.

Experiment: Influence of Color and Beak Occlusion

- Independent variables
  - TargetSize: 6, 9, 12 pixels
  - Exposure: 0.25, 0.5, 0.75, 1
  - Direction: 8 directions
  - Color: gray or colored by dir.
  - Beak occlusion: yes, no
- Results
  - Significant effect for beak occlusion
  - 1-colored icon selection as fast as 8-colored icon selection





Yatani, Partridge, Bern, Newman: Escape: A Target Selection Technique Using Visually-cued Gestures. CHI 2008.

Escape: Advantages and Disadvantages

- Advantages
  - If target big enough, no need to gesture
  - No need to be 100% accurate
  - No need to wait for something to appear
- Disadvantages
  - Each icon takes up more space than original target
  - At screen edge limited gesture directions

The End